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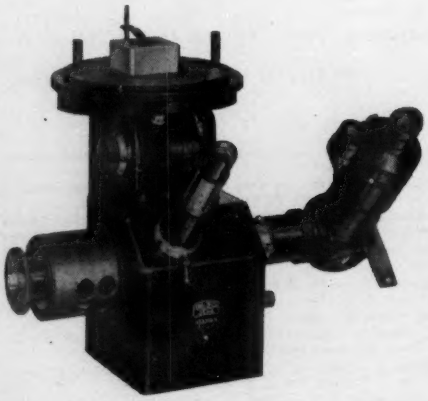

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EXPANSION OF UNIVERSITY EDUCATION IN BRITAIN

THE report on "A Policy of University Expansion", which was adopted by the Council of the Association of University Teachers on December 18, 1957, was only published* in May after the Government had announced a further grant for university building in Britain of £15 million in each of the years 1960–63, and set a target of 124,000 students, with a temporary increase of 10 per cent during the period 1965–70, in place of the 106,000 students previously suggested by the Treasury. In the meantime, however, while the importance of quality in education has received repeated emphasis in various pronouncements on industry and education, and particularly in A. G. Korol's study of Soviet education for science and technology, a series of articles in *Research* on the educational framework of an industrial society have explored further the implications for the universities of the demands of technology. Much attention has also been directed to the question of university awards, and on June 6 the Minister of Education, Mr. Geoffrey Lloyd, announced a new scale of grants for students which, with other changes, will cost nearly £2,000,000 in a full year.

Under the new scales, the parental contribution is decreased while the grants themselves are increased ; and the Minister has also approved increases for students at training colleges for technical teachers which implement recommendations of the Willis Jackson Committee on the supply and training of teachers for technical colleges, besides recommending to local education authorities that students more than eighteen years old pursuing degree or equivalent courses at technical colleges and similar institutions in Britain should receive awards at the university rate. He has also again emphasized the importance he attaches to the maintenance of uniformity in grants to university students throughout the country, and hopes that all local education authorities will adopt the new rates for holders of awards in their own areas. While the increases are roughly double those made three years ago, they increase the disparity between grants for those in training colleges and those for holders of university awards, and, from this point of view, may do nothing to ease the critical shortage of teachers. It could be argued that it would be administratively much tidier to abolish the means test altogether and also the tax allowances for children at a university ; but nevertheless the new scale of parental contribution represents an honest effort to eliminate, within the limits set by the Education Act, what may be described as the 'second surtax' hitherto levied on the higher paid parents of intelligent children. It will not enable every gifted pupil to accept a university place without imposing real sacrifices on his family, but it should reduce further the risk that purely financial reasons will cause some really gifted individual to forgo the training which would develop his talents to the full. Even if it did no more than ensure for the nation the services of half a dozen such outstanding scientists or technologists, the new scale would be worth while ; for what needs to be remembered above all in considering the expansion of university and technological education is the importance, not of seeing that every potential student of marginal ability has a university place, but of ensuring that no boy or girl of really outstanding ability misses one.

We seem, in fact, to be in some danger of expanding university and technological education too much in the former direction. There are limits, as the Chancellor of the Exchequer quite rightly said in the House of Commons, to what Britain can spend even on university education, and it is at least debatable whether the type of university education which the really gifted should receive is exactly that which is best suited to the average university student. We may be attempting to provide many students with a much more expensive type of education than they need and one from which they are unlikely to profit fully.

This may be represented as an attempt to lower university standards, but it indicates the type of question about the nature and purpose of a university education which should be asked in considering the report of the Association of University Teachers and such statements as that of the Labour Party on "Learning to Live". They are no less relevant in discussing particular aspects of university education, such as the founding of Churchill College at Cambridge and the recent statement on university awards, and appear largely to have been ignored by the National Union of Students in its comments on the new scale, though many of the changes are welcomed.

The Association of University Teachers begins with a general discussion of the nature of university education, in which the unique nature of the universities as institutions for both the advancement and the dissemination of knowledge is rightly stressed. The special value of a university education is based mainly on the way in which it brings the student in personal contact with those who are advancing knowledge ; on its unhurried character, in which acquisition of the art of learning takes precedence over acquisition of factual knowledge ; and on the varied types of student and scholar and the branches of learning with which the student is brought into contact. All these features of a good university education could be destroyed if student numbers so increased in relation to the number of teachers as to make research difficult and personal knowledge of individual students impossible, or by

* Association of University Teachers. Report on a Policy for University Expansion. Pp. 14. (London : Association of University Teachers, 1958.) 3*s*.

attempts to produce excessive numbers of fully trained specialists.

This is rightly represented by the Association, irrespective of whether its views as to the practicability of sufficiently increasing the number of university teachers or on the conditions necessary to recruit and retain them are sound. What needs to be emphasized is that it should not be assumed that the student himself is necessarily to advance knowledge. Excessive emphasis on research may increase the cost of a university education, fail to develop many students according to their innate abilities and provide too many graduates of a type and outlook which industry finds unsuitable.

In this connexion, observations on residence and on the size of a university are pertinent, and the paper which Sir Keith Murray read to the Royal Statistical Society on May 14 is of special interest. The Association, stressing the importance of a sufficient leavening of senior members of a university, endorses the view that a university hall of residence should have some 150 students, and it is convinced that new halls of residence are essential to any scheme for a substantial increase in the number of students. Sir Keith Murray is concerned not simply with the possibility that the universities of Britain may become too large to serve the national purpose, but with the effect of the current tendency on the work of the universities themselves—whether we might do better to spend the same amount of money on fewer people, as Lord Woolton recently speculated at Founders' Day in Manchester.

During 1955–56, Sir Keith observed, excluding Oxford, Cambridge and London, sixteen university institutions, containing 35·2 per cent of the students, had less than 2,000 students. By the late 1960's, only four institutions, containing 9·2 per cent of the students, are expected to contain less than 2,000 students, and more than half the university students will be in institutions of more than 5,000. The Government's university building programme already mentioned visualizes an increase of 50,000 students on 1955 by the mid-1960's, and Sir Keith is seriously concerned as to the possibility in such conditions of maintaining the three ancillary freedoms on which the maintenance of freedom of thought depends. That freedom does not require simply freedom from any form of political intervention; it may also be prejudiced by failure to maintain the freedom of a university to make its own appointments to teaching posts, and freedom from external control over either what is taught or admissions.

The universities therefore should not be content to consider expansion mainly in terms of the availability of students of appropriate intelligence quotient. On that basis the Association of University Teachers estimates that the schools could increase the number of pupils taking two subjects in the General Certificate of Education at advanced level by 55 per cent on the figures for 1954, and that the university intake could increase correspondingly. It also estimates that the proportion of the population with high enough intelligence quotient to meet present university entrance requirements is 6·9 per cent compared with the 3·2 per cent who reached the universities in 1954. Even 95 per cent of these would require 145,000 university places by 1965—some 10,000 more than the maximum provided for in the Government's revised plans announced last February.

This, however, is the target which the Association of University Teachers accepts. It suggests that the university population should increase by 35 per cent on 1956–57 by the academic year 1962–63, and by 63 per cent from 1966–67 onwards. Non-collegiate universities should not be encouraged to expand beyond 4,500 students—in other words, to more than double their size—in ten years. This policy would provide a maximum of 23,000 fewer places than the target figure, and the Association suggests accordingly the founding of new universities so that they can make a significant contribution during the period 1961–66. These universities, which should be largely residential, should give their own degrees, initially under the sponsorship of some existing universities. Sites mentioned in the report are Norwich, York and Leamington and, because of the location of many research associations there, Leatherhead. In technology, the Association recommends the use of postgraduate courses to train academically qualified graduates for specialized professional employment.

Even if the assumption that university places should necessarily be available for all school leavers of high enough intelligence quotient to meet existing university entrance requirements is unchallenged—and this ignores the claims of both the colleges of technology and the technical colleges and presupposes that a university education is the most desirable means of training men and women for leadership and responsibility in any sphere of life—targets of that magnitude are best justified on practical rather than theoretical grounds. Sir Solly Zuckerman has recently examined, in the *Universities Quarterly* of May, the implications of the policy of technical education in Britain outlined in the White Paper of 1956, and of the latest proposals for university expansion to provide the estimated necessary output of professional scientists and engineers which would be needed by 1970. During the next ten to fifteen years that report suggested we should aim at an annual output of about 20,000 professional engineers and scientists compared with 10,000 at the time of the inquiry.

If the technical colleges succeed in implementing the White Paper policy, Sir Solly Zuckerman estimates that by 1965 they could supply about 9,500 professional scientists and engineers, including 1,000 with external university degrees. This would rise to about 10,500 by 1970. By the end of the 1960's the university output should rise to 11,000, including 1,500 qualified in special technologies, or 4,500 a year more than in 1955–56. The increase in university places provided in the February 1958 statement should be sufficient to enable the universities to play their part in doubling the present output of scientists and engineers in Britain, and with 20,000 places for students of medicine, dentistry, agriculture and

veterinary science would still leave 50,000 places for the humanities compared with 37,000 in 1955–56.

Sir Solly points out, however, that all this depends on the ability of the schools to supply the entrants. The technical colleges, for example, will require an input of 23,000 by 1967–68, and for the current academic year entries in science and technology are 10,800 compared with 7,300 in 1953. A university population of 124,000 implies an annual entry of 35,000, of whom 2,500 would be from overseas, and the 10 per cent increase would raise this to 38,000 in the late 'sixties. Allowing about half the technical college entry to be from school sixth forms, with some 10,500 for teachers' training colleges, it will be seen that in 1967–68 some 53,000–56,000 from the schools will be required for academic education out of an intake of 64,000–67,000, compared with 37,000 in 1955–56.

Figures like these put the question of teachers in its right perspective, and especially the critical importance of science teachers. If the plans already laid are, in fact, to meet the nation's requirements, their implementation must proceed smoothly and unhindered either by critical shortages or by delays. The Association of University Teachers regards the availability of staff as the most probable limiting factor in the expansion of university education in Britain, and is dubious as to the ability of the universities to recruit a sufficient proportion of first-class honours graduates. It may well be necessary to increase the present proportion of 41 per cent of second-class honours men on university staffs; but the position is one that calls for even greater attention to the efficient use of university staff. The provision of auxiliary staff, known to be comparatively low in universities compared with elsewhere, may be a most important factor in maintaining university standards with a smaller number of highly qualified staff. It is, however, no less important that the needs of further or higher education for those not up to the level of two passes at advanced level of the General Certificate of Education should not be overlooked. As the report on "Early Leaving" indicated, there is here a most important source of the technicians and auxiliary staff on which the most efficient use of the more highly trained scientist, technologist or administrator depends.

The Association of University Teachers cannot fairly be charged with timidity in its approach to university expansion, though it could well be regarded as questioning the soundness of the ultimate target of at least 160,000 places advocated in the Labour Party's statement, "Learning to Live". Nevertheless, in its reference to the universities and to technical and scientific education that statement is reasonable, though the pertinent questions raised about the universities, such as their size, distribution and finance, should, it is suggested, be referred to a royal commission. That suggestion, however, is not without value, and though it seems to lack the urgency needed it could provide some of the safeguards which would encourage constructive response by the universities themselves. There is genuine concern in university circles that a university may cease to be a university if expansion proceeds without due regard to the importance of adequate library facilities, the ratio of staff to students and the balance between different faculties.

No one who studies the annual returns published by the University Grants Committee would suggest that fears on such points are unreasonable. The Association of University Teachers could well have put the case for library expansion much more strongly, for the returns indicate little proportionate attention to the expansion of university library facilities in the post-war years. This, however, is only one illustration of the need for a marked improvement in the real resources of universities, to enable them to make experiments in the curriculum and the varieties of degrees offered, and it is not too much to urge that the higher the proportion of the population entering the universities, the more essential it is that experiments should be made and variety offered.

Prof. Asa Briggs has argued very reasonably in the *National and English Review* for greater differentiation between the universities. The provincial universities should not seek to imitate Oxford and Cambridge, but emphasize and develop their own distinctive advantages. Diversity already exists between the provincial universities, but more is possible, and the greater academic mobility which, as Prof. Briggs points out, is also needed, could assist.

What are needed here—and indeed at all stages in concerting a policy of university or technological or technical education—are vision and judgment, in order to avoid dissipation of resources on secondary objectives and the loss of the full effect of sound measures for lack of essential support at some stage or other. There is substance in the argument, for example, that even the creation of a new college, such as Churchill College, except as part of a considered university policy, could prejudice decisions on vital national questions such as the proper size of Oxford and Cambridge, the location and character of a third residential university, and whether a major new college of technology should be located near some great centre of industry. Without vision, too, doctrinaire considerations may affect adversely critical factors like academic autonomy and the co-operation which is essential from many varied interests and sectors in the national life.

The report of the Association of University Teachers touches on several of these important issues, but by no means all. Sir Solly Zuckerman indicates more clearly how university expansion depends critically upon educational policy in the schools, but even this pragmatic approach by itself is not enough. The continuing need is for independent, uninhibited and constructive thinking about the nature and purpose of university education and their relevance alike to the needs, aspirations and capacities of both students and teachers, and to the needs of the society in which universities exist. Another major consideration is the magnitude of the resources which society can place—and is willing to place—at the disposal of universities, colleges of technology, technical colleges and the schools.

GEOGRAPHICAL DISTRIBUTION OF ANIMALS

Zoogeography

The Geographical Distribution of Animals. By Dr. Philip J. Darlington, Jr. Pp. xi+675. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 120*s*. net.

The Faunal Connections between Europe and North America

By Carl H. Lindroth. Pp. 344. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.; Stockholm: Almqvist and Wiksell, 1957.) 120*s*. net.

THESE two books are both written by experienced taxonomists with special knowledge of the Carabid beetles but much wider interests as well, and both are stamped with the care and integrity of good museum research, backed with a great deal of collecting in various places. Since the publication of A. R. Wallace's classical book on "The Geographical Distribution of Animals" in 1876, there has been no general handbook of zoogeography giving reliable detailed facts about distributions for the whole world, and a balanced, critical assessment of their origins. There have been plenty of interesting essays as well as a lot of very unreliable speculative books and papers, many good regional surveys, studies of island groups or of ancient lakes—a mounting pile of unrelated facts and theories; but nothing one could use for a general interpretation of present distributions and faunal history.

Dr. P. J. Darlington's book goes a very long way towards providing an authentic review of our knowledge of the distribution of vertebrates (to which his analysis is confined), and some way toward fitting them into faunal history. But most of his text is a solid concrete-mix of facts and very closely woven comments upon them, only seventy pages being devoted to a general statement of his views on faunal history as a whole. About a quarter of the book is actually composed of tables summarizing the present and fossil distribution of each family of vertebrates, that is, of the freshwater and terrestrial ones. These are the result of twenty years very careful compilation and checking, and are presented in a thoughtful and critical manner, though in such complex detail that reading is not easy. But any zoologist who enjoys browsing in dictionaries can only emerge from reading this material with an enriched realization of the complexity and interest of zoogeography.

The text has a number of maps, though no list of them is included. The world maps are on an orthographic projection, so that two overlapping maps are needed for a whole world distribution. The author objects to Mercator's projection as misleading; but even though it is a scale convention, I think it much more convenient to look at the world in one piece. The ability of animals to spread quite quickly in the absence of barriers is stressed by the author himself, and this seems to make differences of relative map scale fairly unimportant. He uses wide gridiron markings to show distribution areas, presumably to avoid a misleading appearance of precision in mapping ranges. These make the world look as if it has suffered injuries and been covered with sticking plaster—a convention already suitable to conservation, and perhaps soon also to natural zoogeography.

Dr. Darlington has a highly personal style, his text is laced with decisive opinions, but most of his conclusions seem sound, though perhaps rather conventional. One feels that if a new and daring idea were to be put forward (for example, by another Wegener) he might quickly reply: "But do you realize that didelphids died out temporarily in North America in the Upper Miocene", or some such hard fact—and that in many instances he would probably be right. But many of his opinions cannot be proved, for that is the curse of so much in zoogeography, where the final answers to many of the largest questions must await the further discovery of relevant fossils. One general criticism can be made of the book (which is so genuinely learned and anxious to state conclusions fairly), apart from its lack of ecological ideas. We know that of the great groups of animals like freshwater fish, birds and mammals, that underwent rapid evolution during the Tertiary isolation of continents, good fossil history is available only for some mammals. Most terrestrial and freshwater groups had already evolved far towards a final stage before these continental isolations arose. What we see now is a complicated mosaic of earlier wide distributions now contracted or broken in bits; regional ones attributable to Wallace's 'realms'; redistributions from about the Pliocene onwards; and later blurrings caused by man. For the explanation of most of these patterns we depend on complicated cross-arguments (this book abounds in cross-references) unsupported by a fossil record. This is why a work that concentrates on describing the modern distributions of vertebrates can only include a small amount of proved faunal history to go with it. But zoologists will for many years seek some of their basic facts here, and find them discussed in honest and sensible terms. They will also encounter some ideas that may be new to them, such as the ancient Central American sub-continent that is postulated, and the notion that Madagascar, like New Zealand, may never have been joined to any mainland mass.

Dr. C. H. Lindroth has written a special monograph rather than a book for general reading. It is in three almost equal parts. The first is a detailed tabulation of the present distribution of about 900 species of animals common to Europe and North America, though many of them range much wider, especially into Asia. They include mammals, birds and fish, and a selection of insects, spiders, myriapods, land isopods, molluscs and worms. The list is not claimed to be anywhere near complete, because the author has sensibly chosen groups of species the taxonomy and distribution of which are likely to be reliably known. About 45 per cent of these species include introductions by man. The second part of the book is an analysis of introduced forms, especially those taken accidentally in the ballast of shipping, with some personal surveys of ballast ground-faunas both in Britain and Newfoundland, and a historical survey of earlier shipping trends. It is concluded that introductions by this and other means have been about ten times more common from Europe to North America than in the other direction. The third is the least satisfactory part of an interesting and original monograph, as it discusses in a manner which is rather too condensed a great many controversial questions of faunal history before the influence of man began. Nevertheless, the author has brought

out the rather small common element in the native faunas (at any rate at the species-level) on opposite sides of the Atlantic, and the growing force of invasions made possible by shipping in modern times. There are some good maps, but the book could have been more cheaply printed without loss of usefulness and with more likelihood of being read by students.

CHARLES S. ELTON

EUROPEAN ORTHOPTERA

Die Geradflügler Mitteleuropas

Von Kurt Harz. Pp. xxiii+494+20 plates. (Jena: Gustav Fischer Verlag, 1957.) 69.20 D.M.

THERE has been no book on the Central European Orthoptera since 1901, when the first edition of Tümpel's brief, and now quite out of date, "Die Geradflügler Mitteleuropas", was published. Indeed, with the exception of France, no single country in Europe has its grasshopper fauna covered at all comprehensively, even at the present time. Kurt Harz's book has thus been presented to an entomological public which conspicuously lacks an authoritative work on the Orthoptera of Central Europe. It is true that our knowledge of such aspects as the biology and distribution of European grasshoppers is still little better than rudimentary, but this must be due in no small way to the absence of a publication presenting an up-to-date picture of what facts have so far been established.

The area covered by this book extends east to west from the Rhine valley to the Carpathians, and north to south from the north coast of Germany to the Alps. More strictly, the author regards the following countries as being in Central Europe: Germany, Switzerland, Liechtenstein, Austria, Poland, Czechoslovakia, Hungary, and Roumania. The author, however, recognizes that the Central European fauna has little respect for political boundaries, and he does not therefore exclude Belgium, Holland, Luxembourg, and a strip of northern France. In his introduction, he makes the interesting point that, of the 200 species of his group which occur in the area thus delimited, only 45 occur in Hungary or Roumania or south of the Alps.

Included under the heading "Geradflügler" are the Orthoptera in the widest sense, and the Dermaptera. Following the modern trend, the Blattodea, Mantodea, and Saltatoria are treated as separate orders. Also conforming to recent practice, though less justifiably, many of the groups generally regarded as subfamilies have been given family status.

The arrangement of the book is very systematic and makes for great ease of reference. Even very minor subdivisions of the subject-matter, some occupying no more than two or three lines of print, are given separate sub-headings, and all these, very commendably, are listed in the contents—which occupies a dozen pages. Under each order there is first a general account of the morphology, anatomy, physiology, embryology, and behaviour of the insects included; notes on capture and preservation are also given. Although the information on many of these topics is very brief, the wide coverage of the subject-matter is commendable and greatly increases the value of the book.

Identification keys are given at every level of the classification. A certain amount of ease in identification must therefore have been sacrificed in order to show the natural relationships of the members of each group. For example, the user is obliged to make a critical examination of the subfamily characters (frequently microscopical and often difficult to appreciate) in order to identify a species which may have obvious spot characters.

Under each species the author gives a brief description and notes on the biology of the insect. For the Saltatoria quite comprehensive accounts are also given of the various types of stridulation of each species. The treatment of each insect concludes with a fairly detailed account of its distribution.

The book is profusely illustrated: there are 255 text-figures (including a number of photographs) and 20 colour-plates. Many of the text-figures are redrawn from previously published works but a large proportion is original. These, the photographs, and the colour-plates, are all apparently the work of the author. The standard of the drawings in the text is poor; the intention, evidently, was not to present a high degree of accuracy or to give the illustrations artistic finesse. Difficult points which arise in the identification keys are, however, adequately figured, and a drawing of the whole insect is given for almost every species. The colour-plates are again not of the highest quality, but nevertheless form a most useful supplement to the text-figures. Pictures of some of the different colour-varieties of a few species of Acrididae are wisely included among these plates.

The book concludes with a short glossary of technical terms, a list of abbreviations of authors' names, a comprehensive bibliography including some 500 titles, and indexes to both German vernacular names and Latin names of taxonomic categories.

It should be emphasized that this book is not written for the casual nature lover and is too advanced for even the most ardent schoolboy enthusiast. It is rather aimed at serious naturalists and specialists in entomology, and is sufficiently authoritative and comprehensive to be quite indispensable to any keen student of European Orthoptera. The author has clearly devoted many years to the study of his subject and the literature relating to it; his object in writing the book—to present an up-to-date basis for further studies and to show where the biggest gaps in our knowledge lie—will surely be realized.

DAVID R. RAGGE

MICRO-ORGANISMS IN MILK AND MILK PRODUCTS

Dairy Microbiology

By Prof. Edwin M. Foster, Prof. F. Eugene Nelson, Prof. Marvin L. Speck, Prof. Raymond N. Doetsch, and Prof. Joseph C. Olson, Jr. Pp. xvi+492. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1957.) 5.65 dollars.

THERE are few books on dairy microbiology and their usual pattern is a description of microbial defects in milk or milk products, the naming of the causal organisms and suggested measures for control. The authors of "Dairy Microbiology" attempt first to provide for the reader a foundation of basic information on microbes of importance in the dairy industry, which will enable him not only to have a little insight to taxonomy, but also to appreciate why specific

defects may occur. Before these defects are considered the reader is given a short course (or refresher, as the case may be) on the control of the growth of micro-organisms, their destruction by physical and chemical agents, and the various methods used to examine dairy products for micro-organisms. In the introduction the concept of the speed with which micro-organisms can bring about changes in milk is vividly presented by a discussion of the ratio of cell volume to surface area. A quart of milk soured by *Streptococcus lactis* contains about 10^{12} cells which would present an enzymatically active surface of about 50 square feet.

A small weakness of the book is the rigid insistence on the logarithmic order of death. While such a conception is convenient for the purpose of calculation, this aspect could have been maintained by the statement that for most purposes the speed of reaction was so great that the sigmoid nature of time-death curves could not be determined, and that they appeared to be logarithmic. This would prevent the discriminating reader from puzzling over the reason why one class of biological life should differ from all the rest in that the cells were all of uniform resistance.

It is, of course, relatively easy to make criticisms of any text-book dealing with a wide subject. The applied aspects cover the microbiology of milk on the producing farm, of market milk and related products, of condensed, concentrated and evaporated milk, of ice cream, fermented milks, cheese, cream, butter and waste products.

This book suffers from the defect we have come to regard as usual in American work: insufficient reference is made to European work.

The book is well indexed and illustrated. A 'modern touch' is given to the book by the fact that the illustrations are frequently carried over the margin to the edge of the page. In some cases this allows a saving of space and the reproduction of a larger picture.

While this book is written mainly from the American point of view, a great deal of what it contains is of use to dairy technologists in other continents.

L. F. L. Clegg

ROYAL JELLY

La Gelée Royale des Abeilles

Son Histoire et ses Propriétés, sa Composition—ses Utilisations en Diététique et Thérapeutique Humaines. Par B. de Belvefer. Pp. 470. (Paris: Librairie Maloine; London: Apiserum (James Lowe), 1958.) 4,000 francs; 84*s*.

THIS volume starts with a famous quotation by Pasteur, pointing to the distinction between science and its applications. Unfortunately the material in the book is so arranged that it presents the development of our considerable and diverse knowledge concerning bees just as a prelude to the benefits which, in the author's view, humanity will reap from the uses of royal jelly in various medical fields, such as geriatrics and dermatology. This appears to me to be neither science nor application, but misguided enthusiasm.

The principal merits of the book are that in it are assembled the findings of a great number of workers on the subject in many countries and in various branches of science and medicine; and that interspersed in the French text there are numerous summaries in English, German and Spanish, which—though not linguistic masterpieces—nevertheless greatly facilitate its perusal.

The royal jelly—named by François Huber, the famous blind entomologist—is a secretion of the pharyngeal glands of nursing bees; it is the sole food of queen larvæ and, for about three days, of worker and drone larvæ. It is now widely held that the development of sexuality and the longevity of bee queens is almost entirely due to the continued supply of royal jelly during their larval life; and on this assumption was based the expectation that human sexual drive, vigour, longevity and other positive aspects of health might be improved by the oral use of royal jelly or preparations made from it. In the author's view some of these hopes are justified. The great number of chemical analyses, biological assays and clinical reports contained in the book have, however, not convinced me that royal jelly is a particularly potent drug or that it has any unique therapeutic properties; and in spite of various ingenious hypotheses, the most I would say is that according to the data presented its uses can be described as harmless or slightly beneficial if presumably expensive.

On the other hand, it is legitimate to analyse 'bee milk' in its own right and to study the part it plays in the determination of caste and in the social life of honey bees in general; and for this the book provides much valuable information. One serious mistake on p. 331 is that Butler's queen substance is erroneously identified with the royal jelly. Also it is difficult to understand why von Frisch's experiments on polarized light and on bee language are described in Chapter 6, entitled, "Sécrétion de la Gelée royale". There is no index.

H. Kalmus

DEVELOPMENT OF SCIENCE

Histoire de la science

Publié sous la direction de Maurice Daumas. (Encyclopédie de la Pléiade.) Pp. xlviii+1904. (Paris: Gallimard, 1957.) n.p.

THIS pocket-sized volume, the fifth in the "Encyclopédie de la Pléiade", is designed to constitute a complete synopsis of the historical development of the sciences from their earliest beginnings up to the most recent speculations. It has been prepared under the direction of a distinguished French scholar, M. Maurice Daumas, who, in a thoughtful preface, traces through the centuries the gradual establishment of the history of science as a recognized discipline and discusses the present organization of the subject. Confronted by the growing popular distrust of the scientist and by the competition between humane and technological ideals, he would centre education upon the theme of science conceived as a purposive human activity unfolding itself in history.

In the first of the main articles, M. Daumas follows through the ages the varying fortunes of the typical man of science—his status in society, the economic basis of his activities, and his developing techniques of investigation and communication. The next section, which deals with ancient and medieval science in all its aspects, is from the pen of the late Pierre Brunet, while Robert Lenoble, the biographer of Mersenne, analyses the vicissitudes of scientific

thought in the sixteenth and seventeenth centuries. He deems the modern age to have begun with the earliest conception of a 'mathematical physics' such as Bacon never anticipated but which found full expression in the work of Galileo, the seventeenth-century advances in the techniques of experiment and calculation being motivated by, and not antecedent to, the scientific revolution.

Thereafter the several branches of science, as conventionally distinguished, are separately followed along their parallel lines of development from the sixteenth century to our own day—mathematics by the late Pierre Humbert and René Taton, astronomy by Humbert and Evry Schatzman, physics and chemistry by Maurice Daumas and Rodolphe Viallard, mineralogy and geology by Arthur Birembaut, geography by Antoine Bonifacio, the biological sciences by Maurice Caullery, and the human sciences (comprising anthropology, ethnography, sociology, demography and psychology) by Paul Lester, Paulette Marquer, Alfred Sauvy, Lucien Daumas, François Le Terrier and Gilbert Simondon.

The immense scope of the work has been attained at the cost of a severe condensation of the material, and there is no detailed documentation, although most of the sections are provided with bibliographies. The book is primarily intended to serve as a work of reference; but it should also afford the general reader a useful guide to the intricate pathways by which the sciences have attained their present levels of development.

Errors have not been entirely eliminated from the text. Joseph Priestley becomes "John Priestley" in the introduction (p. xv) although not in the body of the work; and the Doppler displacement suffered by a spectral line in consequence of the recession of the luminous source from the observer should be towards the red and not the violet end of the spectrum (p. 792).

A. ARMITAGE

PARAPSYCHOLOGY TO-DAY

Parapsychology

Frontier Science of the Mind—a Survey of the Field, the Methods, and the Facts of ESP and PK Research. By Prof. J. B. Rhine and J. G. Pratt. Pp. ix+220. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas.) 37*s*. 6*d*. net.

THIS book is by far the most convenient and well-designed summary of the present state of one branch of parapsychology that has yet appeared. The authors believe that the reality of extra-sensory perception (ESP) and psychokinesis (PK) is now fully established and that therefore it is time to take a general survey of the whole subject, indicating where progress has been made in the past and where it is likely to be made in the future.

The book is divided into two parts. In the first section an account is given of the facts as the authors see them and the main problems are discussed. Telepathy and clairvoyance are dealt with, and the case for psychokinesis concisely summarized. General research on extra-sensory perception is then related to that in other subjects, such as anthropology, psychology and psychiatry.

In the second part the most customary testing techniques are clearly described and the commonest statistical methods briefly outlined. The book closes with a few statistical tables, a glossary of terms and indexes to both names and subjects.

As indicated in the foreword, the plan of the book is to state the facts and in the list of authorities to refer to those publications where further information is to be sought. In the opinion of the authors the time has passed when the facts can be challenged except on the somewhat extravagant assumption of what would amount to a widespread fraudulent conspiracy on the part of the investigators themselves. A rational consistency in the expanding knowledge of extra-sensory perception is becoming more and more apparent and, as this increases, what was formerly regarded as something so extraordinary as to be beyond belief tends to become more acceptable because it is more familiar. The authors insist that the phenomena are to be seen as a means of interaction between a person and his universe or, in other words, a method of subject–object interaction. The main difference between this functioning and that on which our ordinary subject–object relations through the sensorimotor system depend, is that the operation is non-physical, although to be objectively manifested it must be converted into observable physical effect. For example, in extra-sensory perception the information acquired must be converted into some conscious experience such as a dream, intuition or hallucination.

On looking back over the past twenty-five years and then consulting this book, the reader can scarcely fail to be struck by the progress that has been made. If new to the subject, he would never imagine that many of the admirable precautions herein described have only been adopted and accepted after long and bitter controversy. Indeed, it is somewhat to be regretted that the authors have seen fit to omit in their references for further reading so many of the important papers which have been published criticizing the methods and experiments of the parapsychologists, since it can scarcely be denied that to some of these critics are due the improvements in technique that have been made.

Although the authors have been mainly concerned with the evidence for and investigation of the phenomena of extra-sensory perception and psychokinesis as seen in action with human beings, they have in more than one place suggested that the phenomena of homing, migration, etc., might be more fully understood if it were recognized that extra-sensory perception occurs and might be relevant. In this connexion they point to the cases in which, it is alleged, some domestic animal, left behind by its owners in its old home, later follows them to their new location, sometimes hundreds of miles away, where it has never been before. Certainly such a case, if properly authenticated, would provide a puzzle to any zoological student; but it is interesting to note that not a single reference is given to any fully described and documented occurrence of this kind.

Apart from occasional examples of this sort, where enthusiasm has perhaps been allowed to overstep its boundaries, the book shows a moderate and restrained attitude which is to be welcomed. As a stimulating account of work in a new and extremely complex field it can be recommended to anybody who thinks of beginning experimental work on extra-sensory perception and similar phenomena.

E. J. DINGWALL

Atomic Energy in Agriculture

By William E. Dick. (The Atoms for Peace Series.) Pp. x+150+16 plates. (London: Butterworths Scientific Publications, 1957.) 15*s*.

THE title of this small book suggests an enormous field and it is fair to say that it deals with only some aspects of this, comprising almost entirely biological applications. The book is mainly a collection of notes (to which explanatory texts have been added to provide the background) of papers relevant to agriculture presented at the International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1955. It would have been of considerable assistance to the prospective buyer if this had been indicated in the title.

The largest and the most interesting chapter is on radiation genetics, which consists almost entirely of accounts of Swedish experiments and of work in the United States. The chapter on photosynthesis, although brief, shares with those on pests and forestry the distinction of being nearly as interesting as the one on radiation genetics. The isotopes oxygen-18 and carbon-14 play the principal parts in this account in elucidating (*a*) the origin of the oxygen evolved during photosynthesis, (*b*) the nature of the primary product of photosynthesis and (*c*) the metabolism of carbon dioxide through the roots. In dealing with pests, the book describes radiotracer studies on the physiology, movement and ecology of insects and animals as well as the metabolism of insecticides by insects. One rather novel use of X-rays from cobalt-60 in pest genetics is described—to produce sterile male flies of the screw-worm—which eventually eradicated this pest from the island of Curaçao. The section on forestry describes the use of bromine-82 at Wisconsin to reveal the existence of root grafts in colonies of trees. The grafts enable nutrient ions to pass from vigorous trees to weaker ones and also allows spores of fungus diseases labelled with silver-110 and iodine-131 to pass from tree to tree. The last chapter deals with the economics and technicalities of food preservation by atomic radiation and gives the reader a good idea of the problems for research which arise out of an apparently simple project. The account of work on 'other elements' attempts to deal with a vast field in a comparatively short space and fails to do full justice, except perhaps in the section on foliar application of fertilizers.

The book is well illustrated and moderately priced. Detectable errors are few; "phosphorus-35" is an obvious printer's error (p. 80) but "millicuries" instead of micro-curies (p. 68 and p. 77) are rather unforgivable slips. A bibliography of all the work referred to would have been much more useful to the reader than the rather pointless index in a book of this kind.

A Monograph on the Termitophilous Staphylinidae (Coleoptera)

By Prof. Charles H. Seevers. (Fieldiana: Zoology, Vol. 40.) Pp. 334. (Chicago, Ill.: Chicago Natural History Museum, 1957.) 6.50 dollars.

AS a systematic monograph this work is unusual in that it is concerned with an ecological unit. It comprises revisions of those groups of Staphylinid beetles which are obligatory inhabitants of termite societies. The Staphylinidae include not less than 25,000 species, mostly predators, but among them are about 300 species which live only in termite colonies. During the long evolutionary history of termites their colonies have been continually invaded by predators, including Staphylinidae, but the chance of any Staphylinid species so adapting itself to the exacting conditions of the termite society as to become established as a permanent inhabitant is very small. It is of interest, therefore, to learn that the present study of the termitophilous Staphylinidae undertaken by Prof. Seevers indicates that the present fauna of some 300 species has arisen from about six pioneer species. From each of the original successfully established species has arisen a natural group (subfamily or tribe) of termitophile species.

The rarity with which termitophile lines have been established finds a parallel in the origin of the insect fauna of remote oceanic islands. It has been pointed out by E. C. Zimmerman that in the Hawaiian Islands, for example, the present-day beetle fauna of 1,290 species is the result of the establishment of only 40 original immigrant species.

The systematic revision of the termitophilous groups, which occupies the greater part of the work, is dealt with in a thoroughly competent manner. The value of the work is enhanced by the fact that the author had available the finest collection of termitophiles in existence, that of Dr. A. E. Emerson, and was able to study all the important type material. It is perhaps to be regretted that there are few illustrations and that photographs have been used in place of line drawings. The author, however, admits this shortcoming and refers the reader to the many previously published figures. E. B. Britton

Introduction to Protein Chemistry

By Prof. Sidney W. Fox and Prof. Joseph F. Foster. Pp. viii+459. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 76*s*. net.

TO many readers the most valuable and interesting feature of this book will be the inclusion in one volume of an outline of the new and improved techniques for the investigation of the composition and structure of proteins and of the results obtained by their application to insulin and to a number of peptides such as gramicidin, tyrocidine, oxytocin and vasopressin. For the rest, the text largely follows the standard arrangement adopted in works on proteins. An innovation is, however, made by including a chapter on the metabolism of the amino-acids and another on enzymes. This is, in my view, a mistake. The proper setting for such subjects is in a text-book on general biochemistry, where they can be, and generally are, treated much more satisfactorily. The space devoted to a descriptive account of particular proteins and protein systems is quite inadequate. Out of a total of 459 pages only 60, of which 24 deal with the blood proteins, are employed for this purpose and of these at least two are occupied with photographs which have no instructional value. In contrast to this, no fewer than 174 pages are devoted to amino-acids and peptides. It is not, therefore, surprising that there is no proper account of the nature of many proteins such as the glycoproteins and lipoproteins; no reference to the phosphoproteins of the yolks of bird or fish eggs despite the statement that the "principal, if not sole, function" of ovalbumin is the nutrition of the young animal; and no mention of histones apart from the unexplained statement that globins "are classified as histones". E. Stedman

AUSTRALIAN COMMONWEALTH DEPARTMENT OF SUPPLY: WEAPONS RESEARCH ESTABLISHMENT*

THE Australian Commonwealth Department of Supply is responsible for conducting scientific research and development in relation to war material for the Commonwealth Government in the same way as the Ministry of Supply for the United Kingdom Government. This function is performed by the Research and Development Branch of the Department of Supply, headed by the Department's Chief Scientist. The Branch operates three research establishments, two of which, the Defence Standards Laboratories and the Aeronautical Research Laboratories, are located in Melbourne, Victoria, and the third, the Weapons Research Establishment, has its headquarters located at Salisbury, near Adelaide (Fig. 1), and operates the guided weapons trials ranges at Woomera. Collectively, the staff of these laboratories, together with the headquarters scientific staff, constitute the Australian Defence Scientific Service.

The Weapons Research Establishment, formerly known as the Long Range Weapons Establishment, was instituted by the Australian Government in collaboration with the British Government. In 1946 the British Ministry of Supply considered the possibilities of a number of sites within the British Commonwealth where a range might be established with adequate supporting facilities for testing guided weapons. The requirements included a range upward of a thousand miles long, over reasonably accessible terrain, without danger to established populations, and with adequate assurance of security. In addition, supporting laboratories and workshops and associated industry were required to be available on a substantial scale. Of the various countries considered, Australia appeared the most promising, and this was confirmed by the report of an exploratory party which the Ministry of Supply sent to Australia in the same year.

In the subsequent agreement between the two Governments, Australia undertook to finance, build and operate the range system now established at Woomera and to set up at Salisbury, some three hundred miles to the south, a centre from which the work could be directed, with adequate laboratories and other scientific and technical support for the range activities. Great Britain would be responsible for the overall policy of guided weapon development and would undertake the basic guided weapon research and development; she would supply the various weapon prototypes for trials, and would undertake their subsequent production.

The accommodation Australia has provided includes workshops for the use of United Kingdom firms which are contractors to the Ministry of Supply for the development of the various guided weapons and which test them on the ranges. At present, some ten firms from among Britain's leading aircraft and electronic manufacturers are established within the premises of the Weapons Research Establishment.

These firms, and much of the joint project activities, rely a great deal for the movement of equipment and personnel on an air ferry service operated by Royal Air Force Transport Command between Lyneham, Wilts, and Edinburgh Airfield, Salisbury, which is part of the Salisbury Establishment. Aircraft, mainly 'Hastings' and 'Comets', supplemented by chartered aircraft, provide a service at about weekly intervals.

Within the Weapons Research Establishment the scientific staff is divided into two wings, one of which is concerned with trials and instrumentation requirements arising from the guided weapons programme, and the other with research and development in fields of aerodynamics, electronics and rocket propulsion for the Australian defence departments.

Each series of guided weapons trials begins with the planning of the facilities that will be required to carry them out. Although much can be done by correspondence between the United Kingdom and Australian technical establishments involved, it is usual for the requirements to be specified in a document which results from round-table conferences in the Weapons Research Establishment, to which the Ministry of Supply and the contracting firms send representatives. The provision of these facilities follows according to the agreed time-table, and later the weapon prototype arrives from the United Kingdom in the charge of technical staff responsible for the trials. Together with Establishment staff, this team produces a detailed specification of all aspects of the individual trials that are to be done, and this is forwarded to the resident staff for implementation.

Many of these trials require the co-operation of aircraft for a variety of purposes, including the provision of pilotless target aircraft. These services are provided by the Royal Australian Air Force Air Trials Unit, which operates from Edinburgh Airfield and Woomera, with headquarters at Edinburgh Airfield, Salisbury. Two airfields have been provided at Woomera. One of them, Evetts Field, is located adjacent to the range head for the operation of the target aircraft ('Jindivik', 'Meteor' and 'Canberra').

Woomera is a town of some 3,000 inhabitants 300 miles to the north-west of Adelaide. It can be reached by rail, road and air, and is maintained in arid surroundings by a water pipe line from the River Murray about 400 miles away. Despite its location, the amenities of living have been provided on a scale which is generally acceptable, and no real problem is encountered in persuading staff to undertake terms of duty there.

The associated testing ranges are laid out over a large tract of country. The main missile range starts from a point some 25 miles from Woomera town and extends in a north-westerly direction to the far coast of Western Australia about 1,250 miles away. Longer range firings to points beyond the coast can be

*Communicated by W. A. S. Butement, O.B.E., Chief Scientist, Department of Supply, Melbourne.

Fig. 1. Aerial view of the Weapons Research Establishment, Salisbury, South Australia

conducted as required. The whole of the territory near the firing line is virtually uninhabited barren country with no large centres of population nearby.

The actual conduct of a trial once the preparation phase is ended is a swift event at any one location, but extends over many miles of territory. This necessitates suitable deployment of the range instrumentation and its maintenance in a state of high reliability and effectiveness.

The quantities to be measured in these trials are concerned with events occurring within the missile itself during flight, with the response of the missile to manipulation of its guidance and control systems, with its trajectory and attitude during flight, and with the performance of its homing system, accuracy of engagement of target, and so on. The apparatus required to effect these measurements includes various forms of telemetry and internal recorders, and ground-based optical- and radio-tracking and velocity-measuring equipment. For many purposes the subsequent recovery of the rocket is a valuable aid to a diagnosis of its behaviour. The ability to make such recoveries is one of the outstanding advantages of ranges over land, and has been exploited at Woomera in a number of ways which in special cases ensure that missiles will neither be lost nor badly damaged.

Among the optical systems in use on the ranges are tracking kine-theodolites (Fig. 2), which record the position of the missile on successive frames of film as a basis for trajectory determination, and large fixed photo-theodolite cameras which, by a series of exposures of a single plate, enable the height and ground-speed of high-flying vehicles to be measured with great precision. In addition, high-speed cine-cameras fitted with telephoto lenses, and carried in power-operated mounts for smoothness of tracking, enable changes of attitude and performance to be examined at selected points along the trajectory. Highly specialized ribbon-frame cameras have been developed for measurements of velocity and acceleration in the early stages of flight. The determination of miss-distance between a missile and target is obtained either from ground photography or from a system of cameras carried in pods at the wing tips of the target aircraft. These cameras have unique properties which include wide-angle lenses with angles of view exceeding 200°, a pair of them providing complete cover of the volume of sky surrounding them.

The electronic instrumentation includes a missile tracking system in which a radiating oscillator is carried in the missile, and a number of auto-follow ground receivers deployed along the range transmit angular information to centralized automatic plotting tables. Various radars and continuous wave apparatus for the measurements of velocity by Doppler methods are also used. A large effort is concentrated in multi-channel telemetry which provides detailed records of the internal operation of the missile during flight.

From this multiplicity of optical and electronic equipment a vast amount of magnetic tape, film and

paper is accumulated, on which the events of the trials are recorded. A data reduction system has been developed and installed at the Salisbury Establishment, based upon a large digital computer called WREDAC, which can process this data at high speed. So far as possible, records are obtained from the ranges on magnetic tape which may be fed into the data reduction machinery directly. In the case of film records, semi-automatic film readers are used for enabling the records to be transformed into forms suitable for mechanical computation with the least possible delay.

In June 1957 a conference on data reduction and automatic computing machines was held at the Establishment and attended by delegates from the United Kingdom and the United States, at which the capabilities of this system of data reduction were demonstrated and a wide range of allied subjects was discussed. Proceedings of this conference are shortly to be published by the Establishment.

A continuous effort is maintained in the investigation of techniques of measurement and recording, and the analysis of the physical processes occurring in trials work ; also in the development, manufacture and utilization of equipment and systems of apparatus for use on the ranges. Effort is also devoted to the investigation of complete missile systems and guidance and control systems both through field experiments and theoretically, the latter with the use of analogue computers. Several analogue computers are in use in the Establishment, including a general-purpose machine of high accuracy called AGWAC.

Research and development work of this nature requires substantial and versatile engineering support. The workshop organization at the Weapons Research Establishment is therefore extensive. The civil engineering work required in the construction at the ranges is carried out under the direction of the Commonwealth Department of Works in accordance with plans and specifications prepared to meet the general specifications of the scientists and engineers at the Weapons Research Establishment.

To facilitate the close liaison needed between the United Kingdom and Australia in the planning of this joint undertaking, the Ministry of Supply has established a nucleus of staff in the Melbourne head office of the Department of Supply adjacent to the latter's Research and Development Branch. A detachment of this United Kingdom staff is also established within the Weapons Research Establishment at Salisbury.

The major part of the activities of the Weapons Research Establishment is thus concerned in the equipping and operating of the missile ranges at Woomera in step with the needs of a continuing and growing activity in British guided-weapon development. The Australian defence organization also has a need for scientific research and development, and

Fig. 2. A kine-theodolite post on the Woomera Range with sliding cover removed ready for use of the theodolites

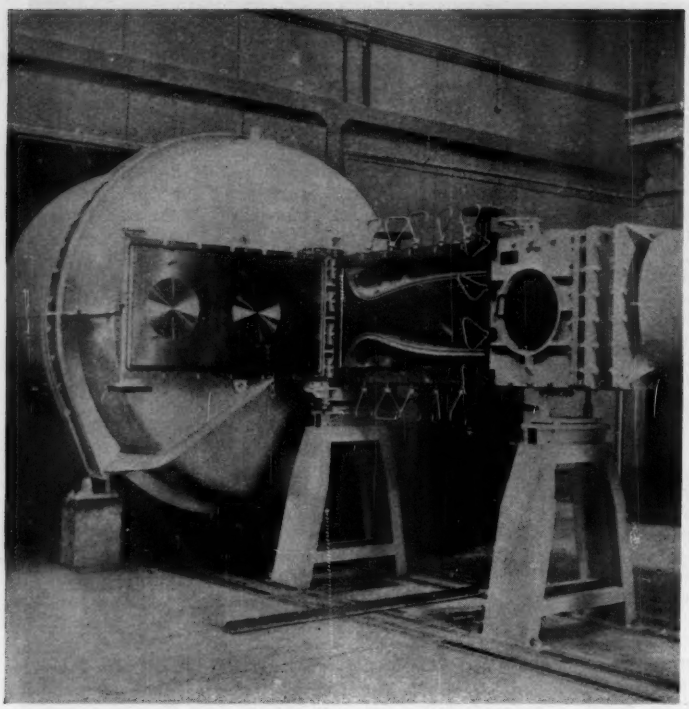

Fig. 3. 15-in. square working section of wind tunnel for Mach numbers 1·4–2·8

this is partly met by the other laboratories of the Weapons Research Establishment.

Research and Development

In Australia, defence science dates in the main from the Second World War. Prior to this, with the exception of the Munitions Supply Laboratories, there was no particular organization equipped to deal with the scientific aspects of warfare, and consequently when the emergency arose the Council for Scientific and Industrial Research, the universities and various industrial laboratories all contributed to provide the scientific effort required.

With the setting up of the Long Range Weapons Establishment in 1947, there evolved the concept of an Australian Defence Scientific Service incorporating also the Defence Standards Laboratories (formerly the Munitions Supply Laboratories) and the Aeronautical Research Laboratories (formerly a division of the Council for Scientific and Industrial Research), to undertake scientific work of a military nature. Certain other specialist laboratories also established in South Australia were incorporated into the Long Range Weapons Establishment in 1955 to form the present Weapons Research Establishment. The scientific staff of these three major establishments and the Research and Development Branch of the Department of Supply now constitute the Australian Defence Scientific Service. The Establishments are controlled by the Research and Development Branch under the direction of the Chief Scientist of the Department of Supply.

The research fields in which the Weapons Research Establishment research and development laboratories are engaged are high-speed aerodynamics, electronics and rocket propulsion. Jointly these laboratories now comprise the Research and Development Wing of the Weapons Research Establishment and are engaged primarily on research projects originated within Australian defence organizations.

The high-speed aerodynamics research is centred in two main facilities, the Woomera Rocket Range and two supersonic wind tunnels at Salisbury. There are many problems for which the free-flight technique offers particular advantages, and the facilities available at the Woomera range for this type of work are being exploited. The range is fully equipped with optical instruments for observing behaviour and tracking, with Doppler radio for velocity and, by differentiation, acceleration measurements, and with ground receiving stations for recording telemetered information from airborne transducers. Projects undertaken on the range have included the investigation of aerodynamic characteristics of rocket-boosted free-flight models, the investigation of the transonic 'area-rule', drag of wing plan-forms at transonic speeds and the flutter characteristics of rectangular wings with various mass distributions.

The 15-in. square continuous flow tunnel (Fig. 3) has a Mach number range of 1·4–2·8 and absorbs 4,000 horse-power under maximum load. The tunnel is equipped with schlieren and shadowgraph for flow visualization and multi-tube manometers for pressure measurement. Aerodynamic forces and moments acting on the model and their changes with varying incidence are measured by strain gauges and recorded in form suitable for analysis by the digital computer WREDAC. The tunnel has been in operation since March 1957.

A small 6-in. square blow-down intermittent supersonic wind tunnel for Mach numbers of 4 or slightly higher with 20 sec. duration of flow is also available.

These tunnels are used for *ad hoc* investigations and for general aerodynamic research, including the measurement of aerodynamic derivatives.

In the field of electronic research, sections are engaged in aspects of electron physics, circuit research, electro-mechanical models, and propagation studies. Applications of the non-magnetic mass spectrometer, for example, to the determination of the composition of the upper atmosphere, are being studied.

Other investigations conducted under the general heading of electronic research include the operation of double-cavity klystrons in the generation of power at micro-wave frequencies, and experiments with methods of reducing the band-width required for transmission of intelligible speech. There appears to be a possibility of achieving a band-width compression ratio of 6 to 1 with a comparatively simple system. Solid-state studies involving materials such as cadmium sulphide and amorphous selenium are in

progress, with the view of their application to storage devices similar in mechanism to vidicon, but not requiring an electron beam or evacuation. The development of infra-red detectors combining sensitivity and short time-constant, particularly for wavelengths of the order 10 μ, and their use in image converters, is being studied.

In the field of chemistry also a considerable range of research and development projects is covered. Studies of the combustion of propellants for rocket motors employ the techniques of flash photolysis and shock-tubes for analysing the chemical reactions occurring and investigating the improvements to the properties of propellants. These properties, and the performance of the motors in which they are burnt, are further tested by static firings in which the thrust and the temperatures and pressures occurring within the motors are measured and recorded by a combination of optical and electronic instrumentation. The high temperatures which occur in these motors require the selective use of materials to withstand them with adequate margins of strength. Materials of the 'cermet' class are being developed for this purpose; the laboratory is equipped with the high-temperature furnaces suitable for the production of such materials. The methods of polymer chemistry are also being employed for the development of plastic and polymeric substances for use in both rocket motor components and propellants with improved physical properties, such as lightness and ability to withstand changes of operating temperature.

As a contribution to the work of the International Geophysical Year, the Weapons Research Establishment is launching two types of rocket for research in the upper atmosphere conducted by various outside research organizations. With radio equipment ('Minitrack') and a Schmidt camera provided by the United States, observations of artificial space satellites are being taken and transmitted to the satellite tracking centres in the United States. The Royal Aircraft Establishment of the Ministry of Supply has designed and built the rocket *Skylark*, which is capable of carrying a payload of 100–150 lb. of apparatus and instruments to heights up to 120 miles. This vehicle is being used by research groups from various universities in the United Kingdom, working under the auspices of the Gassiot Committee of the Royal Society, to investigate air temperatures, densities, winds, the ionosphere, and day and night air glow[1]. In addition, the Weapons Research Establishment is experimenting with the 'rockoon' technique, in which the rocket is launched from a balloon after being lifted to an altitude of 30,000–40,000 ft.

Although the Weapons Research Establishment is primarily engaged in work arising from the joint United Kingdom–Australian agreement for the testing of guided missiles on the ranges at Woomera, it will be clear from the foregoing that the Establishment also conducts a substantial programme of Australian research and development in the field of defence science. The overall Australian defence research effort is, of course, considerably amplified by the work of the other defence research establishments which are centred in Melbourne.

[1] Massey, H. S. W., and Jones, F. E., *Nature*, 177, 643 (1956).

ISAAC NEWTON — CRIME INVESTIGATOR

By Sir JOHN CRAIG, K.C.V.O., C.B.
Formerly Deputy Master and Comptroller, Royal Mint

DR. ISAAC NEWTON was appointed warden of the Mint, with effect from March 25, 1696, during the great silver recoinage, in which historians from Macaulay to Profs. Temperley and Ogg give him a principal role. Their discrepant tributes are all false.

Money in England meant gold and silver coin. In principle, face and bullion value were identical. Unfortunately, grained or lettered rims dated only from the reforms of 1663, and the active silver circulation was mainly composed of worn coins struck long before by outmoded methods. Snipping a sliver of silver off their edges was organized wholesale from the reign of James II by those who handled coin in great quantities. By 1695, repeated small subtractions had robbed the silver circulation of between a third and half of its proper weight. A crisis of confidence set in; recoinage in a modern format had become inevitable.

Since the lost metal amounted in value to a year's revenue, there was a prolonged public controversy on whether it was worse to reduce the legal weights or the numbers of silver coins; whether, in fact, to devalue or deflate. A Commons Committee voted early in 1695 for a slightly disguised 10 per cent reduction of weights. Charles Montagu, Chancellor of the Exchequer, taking with the City of London the opposite view, evaded action. In the autumn, City magnates, scientists—among them Newton—and others were individually consulted. Newton, in view of a rise in the price of silver bullion since the spring, sought a reduction of coin weights by 20 per cent coupled with price control for the duration of the war[1]. His views were totally rejected; Montagu carried his own through Parliament in December.

Moreover, the enabling laws had been passed, the work begun and the Mint's machines and labourers trebled, before Newton was offered his appointment to the most dignified but least effective of the three principal offices of the Mint. Its duties were judicial and negative and it had been a sinecure for a century. Montagu's offer of it on March 19, 1696, did not suggest change. The proposition was "a good proof of my friendship. . . . The office is most appropriate for you. It is the chief officer in the Mint. It is worth £500 or £600 a year, and has not too much business to require more attendance than you may spare"[2].

The emoluments were, in fact, about £415 a year. Further, when, not pleading the letter but because other salaries in the Mint had been greatly raised for the recoinage, Newton asked for an increase for dignity's sake, the Chancellor's own department deferred decision until the recoinage was over; then, in August 1698, it gave him a lump sum[3] of £500, much the same in proportion as his colleagues.

Last, the Commons Committee on the Miscarriages of the Mint[4] explicitly stated on April 8, 1697, that

the successful management of the recoinage was entirely due to the assistant master.

Newton's appointment was a piece of jobbery for a distinguished friend. Such benevolence may have been in mind for some time; it was reported in November 1695 that Newton had been appointed master[5], and in March 1696 it was rumoured that he would be appointed comptroller.

Though Newton took accommodation near the Mint in April or May, he moved in a few months to what was then the extreme west end of London, half an hour away. He retained his Cambridge professorship for the next four years. A small book of my own[6] has set out his activities then and later, but further examination shows that work arising out of coinage crimes was under-stated.

The place of a detective force was sporadically supplied by individual ministers, officials or justices of the peace and common informers, amateur or professional. So far as coinage offences were concerned, such inquiries had been run by a succession of warden's extra clerks; no warden before or after Newton touched this work. But in the May after his appointment, the extra clerk of the moment, George Macey, disappears; and then, if not before, the new warden stepped into the breach.

He was already well acquainted with the underworld by July 30, 1696, when he was summoned before the Lords Justices, the central body of government in the King's absence at the war, to unravel a complicated web of charge and counter-charge. A counterfeiter called Cooke, being condemned to death, bought a respite in May by betraying a number of other criminals and accusing one William Chaloner of theft of dies from the Mint. Chaloner, who was himself seeking a pardon for earlier misdeeds, told the justices that the officials of the Mint themselves supplied dies, tools and false guineas to counterfeiters. Scotch Robin, of the engraver's section, accused Thomas White of the thefts and fled to Edinburgh; White, already under sentence of death for a different crime, accused Hunter and offered information against other criminals.

As Newton investigated this imbroglio, one betrayal led to another until the accused on his hands rose to more than thirty. He interviewed at least half a dozen of them; apart from intermediate correspondence, he attended eight meetings of the Lords Justices, by whom he was further commissioned to examine the security system of the Mint[7]. All this was during the two months of August and September 1696. Other investigations are revealed by an entry in his expense account[8] for September 11, "paid Humphrey Hall to buy him a suit to qualify him for conversing with a gang of coiners of note in order to discover them, £5".

His appeal to the Treasury to be relieved of this attorney's work reveals that he had no assistant and that he interviewed personally prisoners and Newgate solicitors[9]. On November 17 the Treasury sanctioned an extra clerk at £60 a year on the ground of Newton's extraordinary work in detecting and prosecuting clippers and coiners, but the authority may have been anticipated, for the Lords Justices had agreed on August 26 that an assistant was needed, and the salary of Christopher Ellis, the clerk whom he chose, was paid from September quarter day[10].

Newton declared in 1697, what other evidence supports, that his activity had driven many counterfeiters out of London into the provinces beyond the reach of his agents; but the criminal work remained substantial.

The provinces were not neglected. Once at least, on June 9, 1698, he attended at the Treasury to advise on counterfeiting in Yorkshire. In September 1696 he had paid Charles Maris £44 2*s*. for services in Worcestershire and Shropshire; during the summer, another agent, Bodenham Rewse (afterwards head turnkey of Newgate gaol), was paid £34 for prosecutions in these and three other western counties; in March 1697, £40 rewarded Caleb Clark and Joseph Williams for arrests and convictions at Worcester and Exeter; in 1698, Christopher Priddick received £27 7*s*. for convicting seventeen persons out of forty-three charged[11]. Other agents were Taylor, a Holborn engraver, Benjamin Harris, and a little later, John Snow, Botiler, Robert Saker and Richard Morris, who was eventually rewarded with a post in the Mint.

The theft of Mint dies produced a Commons Committee with wider terms of reference to include all "miscarriages". Newton gave the chairman privately a draft Bill for improving the legislation against crime. Amended by the Judges, it was passed during the session[12]. Chaloner, called as a witness, repeated accusations of corruption and inefficiency. The essential reform was to put a practical all-round man in charge of the Mint. To show where this man could be found, he announced two inventions of his own to make counterfeiting impossible—a groove, enclosing a suitable design, in the edges of coins, and an extremely high relief. He undertook to adapt the Mint presses with an enormous future saving.

The Committee was favourably impressed and ordered Newton to bring tools and gear in five days time for Chaloner to demonstrate his methods. Newton, bound under oath not to disclose certain secrets of coining, refused. Neither could he admit the witness to the Mint. But he had pattern sixpences, shillings and half-crowns prepared in high relief and with grooved edges. In the light of this experiment, he assured the Committee that Chaloner's suggestions were expensive, impracticable and useless. These findings were undoubtedly correct. Nevertheless, the Committee reported bluntly on April 8, 1697, in favour of Mr. Chaloner's "better, securer and more effectual way" of coining[13].

Newton in his mortification promised to hang Chaloner, who blamed the final fulfilment of this threat on continuing rancour. It may have been so. Four long holograph memoranda in the Portsmouth collection are devoted to Chaloner[14]; Newton deals there with no other criminal with one minor exception. But the next clashes of the two were accidental.

In August, Newton was called to the Secretary of State's office to examine a suspected counterfeiter, from whom he learned that Mr. Justice Negus had been given full details on May 18 by one of the gang, John Peers, of coinage planned under Chaloner's direction with a new amalgam and improved moulds at Egham, as London had become too risky. He had Peers hauled to the Mint under arrest on August 13, 1697; but as nothing vital had yet been done, released him with a gift of 5*s*. to wait and watch. Peers's visit to the Tower, however, had been noticed, and another of the group had him arrested for counterfeiting. The angry warden visited Newgate next day and bailed out his witness. About the same time he arrested and examined without result a third member of the gang, Thomas Holloway.

On August 31 Newton was called in by the Lords Justices to advise on life or death for the counterfeiter Hicks. He trod on the heels of Chaloner and

his old confederate, Aubrey Price, who had brought a ludicrous story of a Jacobite plot to seize Dover Castle, and a scheme for their own employment as Jacobite couriers, in order to compile lists of the disaffected. Newton revealed the two men's histories and was instructed to arrest them. After a protest that, though building up a capital charge against Chaloner, he could as yet only convict him of a misdemeanour, he clapped the pair in Newgate on September 4. Then Chaloner informed on Price, Price on Chaloner, and two other rogues added denunciations. The Lords Justices showed a great appetite for detail; Newton had to attend five of their meetings to help them. Finally, he asked through the Treasury whether in Chaloner's case he could go back beyond his pardon and was cynically advised by the highest legal authority to discredit the accused over the misdemeanour and proceed to the graver charges when the jury had been biased[16].

During the delay Chaloner suspected trickery, and promised the most dangerous witness against him, Thomas Holloway, £20 to move to Scotland; Newton elicited all the details afterwards. The two other witnesses recanted and Newton's case was summarily dismissed[16].

Chaloner protested to the new Parliament against this high-handed imprisonment in chains, for revelations against the Mint, of a witness before a Commons Committee[17]. A Select Committee was at once set up, on February 18, 1698. The charge of breach of privilege might have been perilous. Newton went over Chaloner's career, exposed some of his lies and defended the arrest, with dates, as unconnected with the previous Committee, but necessary to anticipate a "new and dangerous" way of coining by a notorious criminal. The Lords Justices were not mentioned. Sympathetic at first to the appellant, the Committee found in Newton's favour in terms which he complained were far too brief. Passing to other topics, they compelled his attendance on at least four days in April and May on the accounts of the recoinage[18].

Some time after July 9, 1698, Newton set up his new system of criminal records[19]. This volume contains his examinations of a very large number of criminals, but disproportionate space is devoted to Chaloner, and a number of letters are included, which is done in no other case. It may well have started with an entry a quarter way through of evidence taken against him on October 12, 1698, previous pages being left blank for retrospective entries. Newton's procedure is clear. A witness or suspect was brought before him in the Mint, sworn and questioned; Newton wrote down or dictated a summary of the answers—this is clear from occasional use of the first personal pronoun for the warden. The statement was read to the deponent, who, if necessary, qualified or extended it, and then signed or made his mark. Newton countersigned. Some time after, the accumulated statements were copied into the book. A number were certainly missed; only about half the deponents known from accounts or memoranda appear. Even so, it shows that Newton attended at the Mint for this purpose on at least 127 days from June 1698 to December 1699. The intensity rose to a climax in February 1699, when the Chaloner case was at its peak, with eighteen days attendance, ten of them in succession and including Sundays. This was the "King's business" with which Newton excused himself to Flamsteed in the famous letter of January 6, 1699.

A forgery by Chaloner of Malt lottery tickets, a kind of government premium bond, for which he was betrayed and arrested in October 1698, had nothing to do with the Mint or with Newton. Nevertheless, he collected and had transcribed all the evidence about it, and tipped the useful witnesses. Slowly at first, but much more intensely after the turn of the year, he gathered information about Chaloner's coinage crimes. He even employed in succession, one after the other, as each was seen through by Chaloner, three men whom he had committed to Newgate for crimes, to worm their way into the suspect's confidence and pass on his admissions. Stranger still, he met one of these men in a public house near the prison for oral report and instruction[20].

When after these delays Chaloner was put on trial on March 2, 1699, at the Old Bailey, the lottery ticket forgery was dropped. Newton instead laid three indictments against him: (1) that he had suborned on September 13, 1697, the witness Thomas Holloway to fly; (2) that he had made twenty counterfeit French gold coins in Middlesex on August 25, 1698; (3) that on that day and in that county he had made 10 false guineas, 20 crowns, 40 half-crowns, 20 shillings and 10 sixpences[21].

None could think that 100 counterfeits in two metals and five denominations were made in a single day. The trial proceeded on the third and only capital charge. Newton's six witnesses, all of them criminal and disreputable, were allowed to roam over the past six years without precision as to time or place. Apparently the nearest offence, and that in Surrey, was of forging some shillings in June. Common sense triumphed over the niceties of the law. The jury found Chaloner guilty and he was sentenced to be drawn on a sledge to Tyburn and hanged.

A piteous letter[22] to Newton, detailing all the irregularities of the trial and the prisoner's innocence, had no effect and Chaloner was hanged on March 22, 1699. His gift to Newton at the last moment was grotesque: it was the copper plate for forging the lottery ticket.

Newton continued these pursuits on a diminishing scale until June 1700, six months after he had become master and had been replaced by a new warden, and he resumed them for a short period in 1704. Detection may, after all, have had some appeal for him.

Seven of Newgate's inmates in March 1699 had been committed by Newton, and he probably imprisoned more than a hundred criminals in London alone. A small minority were hanged. Thirteen men and two women were executed in London for coinage offences in 1697; the total fell to eight in 1698[23]. It may be a mere coincidence that London executions for coinage offences practically ceased from 1700 for a few years. The cost was small, less than £300 a year, apart from the large statutory awards given by the Treasury. In addition, Newton was paid his bill for £120 for various small expenses, apparently personal, on coach hire and in taverns, prisons and other places during his wardenship[24].

In the light of the corruption, disorder and chaos which he had experienced, Newton evolved at an unknown date a detailed proposal for a board "above the reach of ordinary corruption" with salaried indoor and outdoor staff wholly financed by the Treasury and unconnected with the Mint, to centralize all evidence, manage all prosecutions throughout the country, and advise on all pardons. Non-co-operative

justices of the peace were to be dealt with through neighbouring benches and the Lord Chancellor[25].

So sweeping and costly a change was not likely to be accepted forthwith; but Newton inserted the thin edge of the wedge in 1715 by the appointment of a solicitor in place of the extra clerk, and the prescription of a scale of fees for each type of case. The ponderous department of the Mint solicitor grew out of this germ. It established a country-wide system, and centralized co-ordination and control long before most of its work was handed over to the new police in 1851.

[1] Manuscript volume No. 62, entitled "Recoinage of 1696", in the Goldsmiths' Library of the University of London.
[2] Letter from the Portsmouth Papers, now in the archives of the Bank of England.
[3] "Calendar of Treasury Papers", **37**, 48; of "Treasury Books", 108 (1698–99).
[4] Printed in Rogers Ruding, "Annals of the Coinage of Great Britain", **2**, 465 (1840).
[5] Luttrell, Narcissus, A brief relation of State Affairs, under date November 5, 1695.
[6] Craig, John, "Newton at the Mint" (1946).
[7] "State Papers Domestic", 177 ff., passim (1696).
[8] Newton MSS. in Mint Library, Vol. 1, leaf 467.
[9] Newton MSS., Vol. 1, leaf 438.
[10] "Treasury Books", 310, 325 (1693–96). "State Papers Domestic", 362 (1696), Warden's Accounts in Newton MSS.
[11] "Try Books", 106 (1697–98). Newton MSS., Vol. 1, leaf 476.
[12] 8 and 9 Will, III c. 26. Newton MSS., Vol. 1, leaf 499.
[13] Ruding, *loc. cit.* William Chaloner, "The Defects in the Present Constitution of the Mint" (1697). Newton MSS., Vol. 1, leaves 499 and 501.
[14] Newton MSS., Vol. 1, leaves 496, 499, 503, 504.
[15] "State Papers Domestic", 339 (1697).
[16] Depositions, etc., Nos. 80, 81, 98, 107 in MS. vol. in Mint Library.
[17] Newton copied out the petition (Newton MSS. Vol. 1, leaf 497), which Chaloner printed and published.
[18] Haynes, Hopton, "Brief Memoirs relating to . . . the Late Grand Coinage of 1696–9", Lansdown MS. 801, British Museum. Williams, O. C., "The Minute Book of James Courthope" (1953).
[19] A manuscript book of depositions, affidavits and letters, mainly July 1698 to December 1699, re-purchased in 1772 by the Mint Assayer from a second-hand book-seller.
[20] Depositions Nos. 130, 134.
[21] Middlesex Sessions Roll, March 1699, Middlesex Record Office.
[22] Copy, Deposition No. 205.
[23] Luttrell, under 16 dates.
[24] "Treasury Books", 200 (1699–1700).
[25] MS. in Newton's hand, Pierpont Morgan Library, New York, printed by David Eugene Smith in W. J. Greenstreet (ed.) "Isaac Newton, 1642–1727", 31–4 (1927).

EARLY WRITING IN GREECE

TABLETS of baked clay inscribed with short statements in two unknown scripts of the later Bronze Age (which in the eastern Mediterranean ended about the eleventh century B.C.) were found in Crete around A.D. 1900. Sir Arthur Evans, their discoverer, named the earlier script Linear *A* and the later Linear *B*. A few examples of Linear *B* were also recognized on the mainland of Greece, but it was not until 1939 at Pylos and 1952 at Mycenæ that the Greek finds became considerable. From the first, it was apparent that many of these tablets were accounts and the numerical system was soon worked out. The other signs number between eighty and ninety and occur in small groupings, so that it was reasonably inferred that they represented syllables and not single consonants and vowels. Though a few entries were accompanied by rough but sometimes recognizable sketches of objects (ideograms), the language was not deciphered; but since Bronze Age (or Minoan) Crete was believed not to be Greek, it was concluded that the language of both Linear *A* and Linear *B* was not Greek either.

The decipherment of the tablets by themselves, though occasionally attempted, was generally considered impossible, and indeed relatively few of them were published. But in 1952, a young British architect, Michael Ventris, who had been working on the problem over a period of sixteen years, announced a solution of Linear *B*. By studying the distribution of the signs he deduced something about the system of grammatical inflexions and the relationships between several of the syllables: if, for example, groups of signs occur which differ only in the last syllable, then there is some likelihood that those last syllables begin with the same consonant and terminate with different vowels. Next he tried to fit ancient Cretan place-names into this framework, and so obtained provisional values for some syllables. The application of these values to other words gave results that looked like Greek, and by experiment values were assigned to most of the other syllables. For the interpretation of his results, Ventris collaborated with an expert on Greek language, John Chadwick, who has continued the task after Ventris's early death. Their "Documents in Mycenæan Greek" is now a standard work.

The Greek obtained by Ventris is at first sight curious. Greek is not a language that lends itself to a syllabary of the type of one consonant plus one vowel, and so final consonants are omitted. Secondly, the deduced syllabary does not distinguish between *l* and *r*; *b* and *p* and *ph*; *g* and *k* and *kh*; or *t* and *th*: so, to take a very extreme case, *pa-te* stands for *pater* and *pantes*, and could stand for some hundreds of permutations conceivable by the rules of Greek word-structure. Thirdly, the vocabulary and grammatical inflexions differ considerably from those of the next Greek documents, composed some 500 years later in the eighth century B.C. Fourthly, the texts of the tablets, as is natural in brief notes, do not often have a normal syntactical form.

In spite of these difficulties, most classical students have accepted the solution of Ventris and Chadwick. They argue that the decipherment works, that for historical reasons Greek was probably spoken in mainland Greece in its Late Bronze (or Mycenæan) Age, when these tablets were written; that their dialect resembles Arcadian, which geography suggests was descended from a dialect spoken in Bronze Age Greece; that some of the word-forms, titles and names were to be expected from linguistic evolution and later legends; and, more cogently, that after the decipherment was published new tablets were found with sketches of objects and descriptions written beside them, and these descriptions make good sense. The disbelievers allege that the proposed rules of spelling are so elastic that Greek of some sort could be read out of almost any hotch-potch of syllables, and that even so, the transcriptions offered are barely, if at all, intelligible. Though some scepticism in detail is needed, it seems to me that in principle the decipherment is convincing.

Any new theory is likely to attract some embarrassing supporters, and many of the interpretations of the tablets are exaggerated or even silly. The tablets so far known number altogether about 5,000,

and most are fragmentary. They are, when complete, flat slabs of clay in sizes generally from 16 cm. × 3 cm. to 30 cm. × 15 cm. and contain from about a dozen to 180 signs. They were used for accounts and short records and, since they were originally unfired, were not meant to be kept long. Those that survive do so by virtue of the accident that the room where they were was burnt down. From this it follows that the tablets we have do not form continuous series, but are, in fact, sets of the same date. The conclusions drawn from this unpromising material are first linguistic, secondly historical.

For the earlier development of the Greek language and changes in vocabulary the tablets are obviously important, though they give little evidence on syntax and many of the forms are ambiguous. They also explain some traditional phrases in Homer, and show that Semitic loan-words had been accepted in Greek by the thirteenth century B.C. Philologists in general appreciate the limitations of this material and their claims are reasonable.

It is very different with historical interpretations. When they speculate on periods that are not fully historical, too many classical students (and prehistorians) cultivate a fundamentally uncritical ingenuity, and the obscure hints of the tablets are a tempting bait. The favourite topics for exegesis are social classes and land tenure (on which, it seems to me, the present evidence is inconclusive) and the relation between Mycenæan society and that presented 500 years later by Homer (which is, in my opinion, tenuous). What is certain is that the ruling groups of Mycenæan Greece used the Greek language, that they worshipped most of the later Greek deities, that some of the names of personages in later Greek legends were current in Mycenæan times, and that there were Greek rulers in Late Bronze Age Crete. Some time in the future, perhaps, a longer document or treaty will turn up to provide more historical illumination. Whether the Mycenæans should be considered as Greeks is another problem, which depends partly on definition. They spoke Greek and were ancestors of the historical Greeks, but their culture was very different, antecedent to but not perhaps significant for the development of the culture which we normally mean when we speak of Greek or Hellenic.

The volume* the appearance of which has provided the occasion for this article almost completes the publication of all the tablets found up to last year. A. J. B. and E. B. Wace explain the circumstances of their finds, Bennett illustrates, describes and transcribes precisely, and Chadwick comments with careful judgment. Incidentally, there is some useful information for the history of botany. The indexes are full. The evidence is now admirably presented for other students to use or misuse.

R. M. Cook

* Transactions of the American Philosophical Society. New Series. Vol. 48, Part 1: The Mycenæ Tablets II. Edited by Emmett L, Bennett, Jr. Translations and Commentary by John Chadwick. Pp. ii+122. (Philadelphia: American Philosophical Society, 1958.) 3 dollars.

OBITUARIES

Viscount Bledisloe of Lydney, G.C.M.G., K.B.E.

On July 3, Viscount Bledisloe died at his home at Lydney, Gloucestershire, in his ninety-first year. He was one of the first members of Parliament to take an interest in agricultural science, when rather more than fifty years ago it was breaking away from the ideas of the mid-nineteenth century that had long dominated it and began to develop on modern lines. In its earlier days, agricultural science had been largely concerned with finding solutions to farm problems; it had almost reached a dead end. The new purpose was to study the relations between the growing plant and its environment without regard to whether the results might have any bearing on agricultural practice.

Lord Bledisloe, then Charles Bathurst and member of Parliament for Wilton, was one of the few in authority who recognized the soundness of this approach. British agriculture was very slowly beginning to emerge from a severe depression that had lasted for some twenty years, and he constantly urged the Government to help it; he was almost alone in this, but he never lost heart. The Government went so far as to promote agricultural education, but would do nothing for the new type of agricultural research. He realized that agricultural education, to be effective, must be based on a sound agricultural science, and when finally the Lloyd George Development Fund was set up, out of which research could be financed, he actively supported the first expansion of Rothamsted Experimental Station in 1912. Later, as chairman of the governing body of the Station, he was a frequent visitor to the laboratories and made a point of knowing the members of the staff and the chief lines on which they were working. A new block of laboratories for plant pathology was built during his term of office. As chairman, his policy was to maintain the links between agricultural science and agricultural practice. This was acceptable to the leaders of the new science, who realized that it would inevitably become increasingly complex, and might, unless care were taken, become lost in the infinite spaces of pure science.

He was equally interested in the application of science to the improvement of animal health, and did much to ensure that the new knowledge should reach even the small farmers. One of the results has been the elimination of tuberculosis from many dairy herds and even from an entire county.

In 1928, he became chairman of the Imperial Grassland Association and took an active part in the awakening of interest, both practical and scientific, in the grasslands of the Commonwealth, which has led to remarkable developments in many countries. This work, however, he soon had to give up, as he was appointed Governor-General of New Zealand. The choice was a particularly happy one. He was peculiarly well qualified for the post, and filled it with great distinction, aided by his charming wife. His lively interest in the pastoral industry, New Zealand's chief source of wealth, based on personal knowledge and experience of livestock gained on his farm at Lydney, enabled him to meet farmers on their own ground, and his obvious pleasure in making direct contact with them greatly endeared him to them. His interest in the scientific workers and

their problems was equally marked, and equally rewarded.

Lord Bledisloe will long be remembered with affection by those who were privileged to know him, and with deep respect by the many who in farms, villages or research stations had benefited by the encouragement he always gave to those trying to raise the standard of country life.

E. John Russell

Dr. Rosalind E. Franklin

The news of the death of Rosalind Franklin on April 16 came as a shock to many workers in the field of biochemistry and virus studies. It is a special tragedy when a brilliant research worker is cut off at the height of her powers and when exciting new discoveries are expected from her.

Rosalind Franklin was born in London on July 25, 1920, the elder daughter of Mr. and Mrs. E. A. Franklin. She was educated at St. Paul's School, London, and Newnham College, Cambridge, and started her scientific career after studying physical chemistry at Cambridge. Her first employment was in the British Coal Utilization Research Association, where she worked under Bangham on the colloidal properties of cokes and chars. She showed that although the total volume of the pores in the coal increases continuously with increasing temperature, their accessibility decreases, so that finally even helium molecules are unable to penetrate them.

It must have been apparent to her then that it would be impossible to reach an understanding of coals and chars without the use of X-ray diffraction methods. These she was able to acquire when she transferred in 1947 to the Laboratoire Centrale des Services Chimiques de l'État in Paris. Her three years in Paris working with Méring taught her to appreciate the value of monochromatic X-rays for low- and high-angle studies of amorphous substances where bands of indefinite intensity replace the sharp spots given by the more perfect crystals. It was, however, a combination of these analytical techniques with chemical preparatory skill that enabled her to unravel the major processes concerned with the transformation of practically all organic substances into different kinds of chars on heating. In a series of beautifully executed researches she discovered the fundamental distinction between carbons that turned into graphite on heating and those that did not, and further related this difference to the chemical constitution of the molecules from which the chars were made. These studies are of fundamental interest both for the old industry of coking and for the new one of graphite moderators in atomic piles.

Miss Franklin might well have remained in this field in which she had made her name, if she had not been more attracted to that of biophysics, where she was able to turn her newly developed skills to investigate the structure of large molecules of biological importance, particularly in nucleic acids and the viruses.

In 1951 Miss Franklin was awarded a Turner–Newall Fellowship to work at the newly established Biophysical Laboratory at King's College, London. Without any previous biological experience, but with a great grasp of X-ray techniques and their chemical implications, she arrived at a fortunate moment, when X-ray crystallography was breaking away from the more limited field of the study of regular crystals to those in which the molecules were only partially ordered, and in particular those in which the essential form was that of the spiral. Her first paper in this field was one of three in which the first was the now classical paper of Watson and Crick on the double-spiral hypothesis for the structure of deoxyribonucleic acid. In this close collaboration between the Cambridge and London schools it is difficult to disentangle all the contributions of individuals, but what Miss Franklin had to give was the technique of preparing and taking X-ray photographs of the two hydrated forms of deoxyribonucleic acid and by applying the methods of Patterson function analysis to show that the structure was best accounted for by a double spiral of nucleotides, in which the phosphorus atoms lay on the outside.

In 1953 Miss Franklin left the Unit at King's College to take up the direction of research on virus structure at Birkbeck College, London, where her work was supported first by the Agricultural Research Council and later by the United States Department of Health. Here her main study was on tobacco mosaic virus. She took up its X-ray study where it had been left in the work of Bernal and Fankuchen fifteen years before, using her improved techniques. Watson had put forward the hypothesis that the virus structure was also spiral, but one of quite a different order from that which existed in proteins and in deoxyribonucleic acid. Miss Franklin, with the help of very much better X-ray photographs than had hitherto been obtained, was able in essence to verify this hypothesis and to correct it in detail. It was at this point that the extremely fruitful co-operation began between Miss Franklin's unit and Fraenkel-Conrat at Berkeley, Caspar at Yale, and Schramm at Tübingen. Using the method of isomorphous replacement, she showed that the virus particle was not solid, as had previously been thought, but actually a hollow tube. Miss Franklin's greatest contribution to this study was to compare the radial density map of the intact tobacco mosaic virus with that of the nucleic acid-free particles, in which the protein units had been re-aggregated without the ribonucleic acid. This showed that the ribonucleic acid was not to be found in the central cavity but embedded in the protein.

It would also appear from work still unpublished at the time of her death that the ribonucleic acid is in the form of a single strand, following the spiral of the virus particle, thus being very different from the double-wound helices of the deoxyribonucleic acid of the bacterial viruses and higher organisms. The combined methods of chemical preparation and X-ray examination in the hands of Miss Franklin and her associates was a valuable, and indeed a decisive, weapon in the analysis of these complex structures.

As a scientist Miss Franklin was distinguished by extreme clarity and perfection in everything she undertook. Her photographs are among the most beautiful X-ray photographs of any substance ever taken. Their excellence was the fruit of extreme care in preparation and mounting of the specimens as well as in the taking of the photographs. She did nearly all this work with her own hands. At the same time, she proved to be an admirable director of a research team and inspired those who worked with her to reach the same high standard. Her devotion to research showed itself at its finest in the last months of her life. Although stricken with an illness which she knew would be fatal, she continued to work right up to the end. Her early death is a great loss to science.

J. D. Bernal

NEWS and VIEWS

Atomic Weapons Research Establishment : Dr. Nyman Levin

Dr. Nyman Levin has been appointed by the United Kingdom Atomic Energy Authority to be a deputy director of the Atomic Weapons Research Establishment. Dr. Levin, who was born in 1906, graduated at the Royal College of Science, London. During 1930–40 he was with Marconi (Research and Development) and then he was seconded to the Admiralty to work with the Royal Naval Scientific Service. He transferred to the permanent staff in 1946. He was appointed superintendent of the Admiralty Gunnery Establishment in 1951. Since 1955 he has been chief of research and development to Rank Precision Industries. When he joined the Admiralty, Dr. Levin was engaged on the development of microwave valves ; he started work in Bristol at what ultimately became the Services Electronics Research Laboratory. He carried out development work on microwave receivers and then was responsible for the establishment of cross-channel V.H.F. links, as part of the preparation for the invasion of Europe. This involved building a chain of stations along the south coast of Britain and confirming the reliability of V.H.F. communications over very long distances. Soon after the War ended he became head of the Instrumentation Group at the Admiralty Research Laboratory, where the underwater television technique was developed. With Rank Precision Industries he has been responsible for the development in Britain of xerography—a technique of dry electrostatic photocopying—and its applications, including the high-speed printing of computer outputs.

Theoretical Physics at Nottingham : Prof. K. S. H. Stevens

Dr. K. S. H. Stevens, who has been appointed to the chair of theoretical physics in the University of Nottingham, was educated at Magdalen College School, Oxford, from which he won an open mathematical scholarship at Jesus College. After two years residence he joined the Admiralty Research Group at the Clarendon Laboratory in 1942 and returned to Jesus College in 1945. He was awarded first-class honours in the Mathematics Finals of 1947 and was Harmsworth senior scholar of Merton College during 1947–49. He obtained the D.Phil. degree for theoretical physics in the latter year. During 1949–53 he was research fellow of the Pressed Steel Company at Oxford, and during 1953–54 was in residence at Harvard University. Dr. Stevens was appointed reader in theoretical physics in the University of Nottingham in 1953. His main interests at Oxford were in the theory and magnetic properties of ionic salts, and more recently he has been concerned with the ferromagnetism of metals and alloys and other aspects of magnetism, including applications to micro-wave amplifiers.

Agriculture at Nottingham : Dr. J. D. Ivins

The appointment of Dr. J. D. Ivins to the chair of agriculture at the University of Nottingham, vacant since the resignation of Prof. H. G. Robinson in 1954, will be welcomed by his friends throughout the United Kingdom. Dr. Ivins graduated from the University of Reading with honours in agricultural botany in 1944, and was appointed almost immediately to the National Institute of Agricultural Botany at Cambridge. His connexion with the University of Nottingham was made in 1945, when he went as crop recorder to the School of Agriculture at Sutton Bonington. He became lecturer in crop husbandry in 1948, and was invited to become acting head of the Department of Agriculture in 1955. Dr. Ivins has been an active member of the Agricultural Education Association and of the British Grassland Society, and since 1956 has been recorder of Section K of the British Association. An able and inspiring lecturer, he has already made noteworthy contributions to the welfare of the School, in the reorganization of the University farms, and by the extensive and effective liaison he has built up with numerous sections of agriculture and its related industries. At the same time he has developed and encouraged an effective school in the Department of Agriculture, where he has initiated two lines of research. The first, which arises logically from the theme of the Nottingham School, is the effect of cultural practices on the growth of the potato crop. The second, which is more peculiarly his own, is an attempt to bridge the gap between crop and animal husbandry by a study of the utilization of grass by the grazing animal. His use of small balanced herds of identical twins has given a precision to measurement that has not hitherto been possible, and the more critical evaluation of pasture productivity that results affords interesting potentialities for the future.

Chair of Heat Transfer in London : Prof. D. B. Spalding

Dr. D. B. Spalding, whose appointment to the new University chair of heat transfer tenable at the Imperial College of Science and Technology, London, has just been announced, is well known for his work in the general field of thermodynamics and heat transfer. His research interests in the past few years have been concerned in particular with problems of temperature distribution and heat transfer in combustion processes, and with the thermodynamics and mass transfer in boundary layers, particularly in high-speed flow. He has developed and exploited a number of analogue methods for the solution of the equations that arise in these connexions, some of them electronic and others mechanical analogues in the true sense. His new appointment marks a further stage in the planned expansion of the Mechanical Engineering Department at the Imperial College of Science and Technology, as the completion of the first stage of the new Engineering block makes available some more room for experimental work in heat transfer.

Royal Commission for the Exhibition of 1851 : Awards for 1958

The Royal Commission for the Exhibition of 1851 has awarded the following senior studentships for 1958 for research at the universities indicated : Miss I. C. Gardner (Glasgow), for research in plant biochemistry ; P. B. Jones (Oxford), for research in nuclear physics ; M. P. Kerney (Imperial College of Science and Technology, London), for research in palæontology ; G. W. Kirby (Cambridge), for research in organic chemistry ; P. A. G. Scheuer (Cambridge), for research in radio astronomy. The Commission has also awarded the following overseas scholarships for 1958 : I. G. Macquarrie (Dalhousie University),

for research in botany at King's College, London; E. A. Ogryzlo (McGill University), for research in physical chemistry at Sheffield; W. R. Frisken (Queen's University, Kingston), for research in nuclear physics at Birmingham; D. W. Cameron (University of Queensland), for research in organic chemistry at Manchester; D. H. Green (University of Tasmania), for research in geology at Cambridge; R. M. Freeman (University of New Zealand), for research in physics at Cambridge; Miss A. J. Alexander (Rhodes University), for research in zoology at Cambridge; M. E. Mitchell (National University of Ireland), for research in ecological botany at the University of Rennes; G. B. Venkata Subramanian (University of Delhi), for research in organic chemistry at Cambridge; M. M. Islam (University of Dacca), for research in physics at Birmingham.

The National Chemical Laboratory

The Lord President of the Council has approved changes in the functions of the Chemical Research Laboratory at Teddington, Middlesex, proposed by the Council for Scientific and Industrial Research, and the name of the Laboratory has been changed to the National Chemical Laboratory. The Laboratory will concentrate its effort on a few objectives, covering only a limited part of the whole field of chemical research, so as to be able to make a real impact on selected problems of national importance such as the following: (*a*) Problems which are appropriate neither to industrial research laboratories nor to universities, because of the necessity for special facilities, experienced staff and continuity of effort. These include the determination of the fundamental physico-chemical properties of chemical compounds which are required, for example, by chemical engineers for the design of full-scale industrial plant. The related study of the development of techniques of purification of materials such as metals and chemicals, with the view of supplying standard samples of pure substances for reference purposes, is also in this category. (*b*) Problems, the solutions of which are of national economic value and have wide general applications to many industries, for example, fundamental and applied studies of the corrosion of metals, which has been estimated to cost Great Britain about £600 million a year. (*c*) Problems, the solutions of which are urgently required in connexion with the nation's atomic energy programme; these are mainly concerned with the extraction of elements of atomic energy interest from low-grade ores. The change in the name to the National Chemical Laboratory has been decided upon to emphasize that its main purpose will be to undertake selected fundamental and applied chemical researches of national importance, which could not otherwise be worked on by any existing organization.

Windscale Pile No. 1

The Atomic Energy Authority has decided that it would not be economic to repair Windscale Pile No. 1. The maximum technical information which can be derived from examination of the reactor core is being obtained, and useful materials and equipment will be recovered. Some of the buildings will be adapted to other uses and the remainder sealed off. The operatives hitherto employed on this reactor are now engaged on other activities at Windscale which are expanding.

Moral Implications of Atomic Energy

In his Burge Memorial Lecture delivered on April 15 at Church House, Westminster, which has now been published ("Ethical and Political Problems of the Atomic Age". Pp. 22. London: Student Christian Movement Press, 1958. 2*s*. net), C. F. von Weizsäcker discussed some ethical and political problems of the atomic age, as a scientist, as a citizen of the Western world and as a Christian. Beginning with the observation that the most conspicuous political event of 1957 was the appearance of the first Soviet Earth satellite, he points out that this technical achievement became a political event because of its psychological effect, and that such developments pose the problem of the adult man, no longer protected like a child, who can survive only if he creates for himself the conditions of life. Dr. von Weizsäcker himself believes that the spiritual foundations of the technical world are dependent upon Christianity. Pointing out that Western freedom is guaranteed only by the certainty that mortal blow will be answered with mortal blow, he maintains that this is a very precarious guarantee. After examining the measures proposed for avoiding the present dangers, he concludes that, in principle, it would be sensible to strive for the total abolition of war by all prudent means and that such attempts have a good chance of success. It is, however, the policy of the Soviet Union to undermine the strength of the West by exploiting the prevalent and understandable antipathy to nuclear weapons. The belief that such weapons will effectively protect our peace and freedom is itself a well thought-out ideology containing strong elements of truth, but its effect is to cripple our wills. Dr. von Weizsäcker does not think that the Church as an institution is in a position to suggest the renunciation of the hydrogen bomb on a basis of political responsibility; those who have already experienced something of this crisis would render their fellow-men a service by dissociating themselves from all participation in matters connected with such weapons. The value of passive resistance and of more conventional political methods requires much fuller examination.

Preservation of Rural England

The twenty-seventh annual report of the Sheffield and Peak District Branch of the Council for the Preservation of Rural England, presented at the annual meeting on May 31, stresses the failure of Parliament to respond to the urgent plea that the Land Fund, understood to be designed for National Parks, should be put to that purpose. In consequence, the National Parks Act is ineffectual, and the same lack of vision, the report urges, is shown in the siting of nuclear power stations in the very areas the National Parks Act was framed to protect. The Branch fully supports the stand being made against the proposal to site such a station on Trawsfyndd Lake. Tribute is paid to the competent control constantly exercised by the Park Planning Board in the Peak District National Park, and the Board and the Branch are supporting the petitioners against the proposed Chew Valley reservoir, which would take all the remaining farmland and spoil the fine approaches up the Chew Valley to the moors of the National Park. With the National Parks Commission and the National Trust, the Council and its local branches have indicated their opposition to the proposed motor road in the Manifold Valley. Adverse comment is

also made on the proposal to erect a steel lattice-tower 150 ft. high for a police radio transmitter and on the continuance of threats from opencast coal-mining, notably at Barlow. However, the arrangement between the General Post Office and the Peak Park Planning Board covering the whole Peak regarding proposals likely to affect the landscape, and of the Sheffield Corporation's policy towards tree planting, receive favourable mention.

International Certification of Herbage Seed

As a result of a certification scheme introduced by the Organization for European Economic Co-operation, the farmers of Europe will in future be able to rely on the qualities and types of seed for grasses and legumes offered for sale. In the past, confusion has arisen due to differences in nomenclature and methods of certification between countries. Hitherto, herbage seed offered in international trade has fallen into two categories: uncertified seed and seed certified in accordance with various national systems. The effect of the new rules and directions approved by the Organization for European Economic Co-operation is the introduction of a third category—herbage seed bearing an international certificate and a special label issued under the authority of the official seed-certifying agencies in member countries of the Organization. The scheme is open to any of the seventeen member countries and will operate for an initial period of five years. Copies of the rules and directions can be obtained from the Director of Agriculture and Food of the Organization for European Economic Co-operation.

Colleges of Technology in Britain

In a written answer in the House of Commons on June 18, the Minister of Education, Mr. Geoffrey Lloyd, listed the following colleges as approved, up to the present, as colleges of advanced technology: Birmingham College of Technology; Bradford Institute of Technology; Battersea College of Technology; Chelsea College of Science and Technology; Northampton College of Advanced Technology; Loughborough College of Technology; Salford Royal Technical College, and the Welsh College of Advanced Technology, Cardiff. Those approved as regional colleges are: Brighton Technical College; Bristol College of Technology; Brunel College of Technology, Acton; City of Liverpool College of Building and City of Liverpool College of Technology; Glamorgan College of Technology, Treforest; Huddersfield College of Technology; Kingston-upon-Thames Technical College; Leicester College of Technology and Commerce; North Staffordshire Technical College, Stoke-upon-Trent; Nottingham and District Technical College; Plymouth and Devonport Technical College; Portsmouth College of Technology; Rugby College of Technology and Arts; Sunderland Technical College; West Ham College of Technology; and in London, the Borough Polytechnic, Southwark; Brixton L.C.C. School of Building, Lambeth; Northern Polytechnic, Islington; Sir John Cass College; The Polytechnic, St. Marylebone, and Woolwich Polytechnic.

Imperial Cancer Research Fund

The fifty-fifth annual report of the Imperial Cancer Research Fund for 1956–57 (pp. 45. London: Imperial Cancer Research Fund, 1958), besides its survey of current work, refers to the approval of plans to build in Lincoln's Inn Fields, London, new and adequate laboratories adjoining the Royal College of Surgeons. The initial building costs are estimated at £600,000, and about £250,000 will be required for furnishing and equipping the laboratories, with an additional annual £150,000 for maintenance. The new research laboratories will provide accommodation for the chemico-pathological research at present being carried out at No. 48 Lincoln's Inn Fields, but will also permit a big expansion in the research programme of the Fund. Current work at Lincoln's Inn Fields is concerned mainly with the relation between hormones and human cancer, concentrating on cancer of the breast and of the prostate. An important part of the service there is the work on the early diagnosis of cancer by the study of smears of secretions. At the Mill Hill Laboratories fundamental biological research is largely concerned with tumour growth in animals and the characteristics of various malignant tumours. Dr. J. Craigie has perfected a method for storing tumours in a frozen state at − 32° C. for four to seven years, and human tumours, removed at operations or at post-mortem examinations, are being transplanted into laboratory animals so that the effect of different agents on cell growth can be observed. The reaction of tumour cells to changes in environment is being studied with an ingenious kine-microscope with 'Perspex' observation chambers. Lists of papers published from the Laboratories since the last annual report are included in Dr. Craigie's and Prof. G. Hadfield's reports on the work of the Laboratories.

Soviet Crystallographic Meeting

The sixth general meeting called by the Commission for X-ray Diffraction of the Academy of Sciences of the U.S.S.R. was held in Leningrad during June 23–29. Some 900 people, including ten foreign guests, attended the opening session, which was addressed by the chairman of the Commission, Prof. G. S. Zhdanov (Moscow). The meeting proceeded in seven sections devoted to the X-ray study of alloys; X-ray studies of deformed metals; X-ray structural analysis and crystal chemistry; apparatus and methods of X-ray structural analysis; X-ray spectroscopy; electronography; and X-ray and γ-ray defectoscopy. The total number of papers contributed in these specialized sections was 333, and in addition there were twelve contributions during the full sessions. The rapid growth of crystallographic research in the Soviet Union is evident from this meeting, and from the reported production of sealed X-ray tubes in the U.S.S.R., namely, 3,887 tubes in 1957 and 4,700 in 1958. After the meeting most of the foreign guests travelled to Moscow and had opportunities of seeing the crystallographic work in progress in various institutes.

Travelling Fellowship and Student Prizes in Psychiatry

Mr. J. A. Baldwin, a medical student at the University of Aberdeen, has recently been awarded the first of the Mental Health Research Fund Travelling Fellowships. These are awarded annually to medical students, selected by an essay competition and interview, by the Mental Health Research Fund (39 Queen Anne Street, London, W.1), for special training in psychiatric or other departments abroad for six months. The Fund hopes in this way to stimulate interest in mental health and, particularly,

in research bearing upon it, at an early stage in the student's career. The subject of the essay was "The Relative Importance of Nature and Nurture in the Development of Psychiatric Disorder". In addition to the Travelling Fellowship, three cash prizes have been awarded: £100 to Dr. G. Sedman, Manchester Victoria Memorial Jewish Hospital; £50 to Mr. J. D. Swales, Westminster Medical School; and £25 to Mr. A. P. K. John, Pembroke College, Oxford.

Institution of Civil Engineers

The following were recently elected to office in the Institution of Civil Engineers: *President*, Prof. A. J. S. Pippard; *Vice-Presidents*, A. C. Hartley, Sir Herbert Manzoni, Sir George McNaughton, R. W. Mountain; *New Members of Council*, L. Carnie (Glasgow and West of Scotland), N. S. Cox (South Western), A. Dean, S. E. Faber (Colonies), J. R. Farquharson (Colonies), J. T. D. Firth (North Western), O. Holden (Canada), W. P. F. McLaren (South Africa), T. P. de S. Munasinghe (Ceylon), R. H. Roberts (Northern and Southern Rhodesia), J. F. Stanbury, R. W. Taylor (Colonies).

University News: The Queen's University, Belfast

The following appointments have recently been made in the Queen's University of Belfast: Dr. G. Seth, to the chair of psychology; Dr. H. G. Heal, to a lectureship in inorganic chemistry; Mr. T. K. Marshall, to a lectureship in pathology (forensic medicine).

Birmingham

The following appointments in the University of Birmingham have recently been announced: Prof. D. L. Linton, professor of geography in the University of Sheffield, to the chair of geography, made vacant by the retirement of Prof. R. H. Kinvig, from October 1; Dr. P. J. Hilton, senior lecturer in mathematics in the University of Manchester, to the Mason chair of pure mathematics, made vacant by the resignation of Prof. C. A. Rogers, from October 1; Mr. I. T. S. Essery, to be senior lecturer in civil engineering; Mr. D. M. G. Wishart, to be lecturer in statistics in the Department of Pure Mathematics; Dr. J. D. Young, to be lecturer in physics; Drs. K. J. Morgan, R. S. Lehrle and J. D. Hobson, to be lecturers in chemistry; Dr. R. E. Smallman, to be lecturer in physical metallurgy; Mr. G. R. Coope, to be lecturer in geology; and Mr. N. Dennis, to be lecturer in sociology. The title of reader in mathematical physics has been conferred on Dr. G. E. Brown, lecturer in mathematical physics, from October 1.

Bristol

The following appointments in the University of Bristol have recently been announced: Mr. J. M. Cook, reader in classical archæology in the University, to a chair of ancient history and classical archæology; Dr. J. W. F. McOmie, to a readership in organic chemistry; Mr. R. W. Marsh, to a readership in plant pathology; Dr. Suzanne K. R. Clarke, to a lectureship in bacteriology.

London

The title of professor of pure mathematics in the University of London has been conferred on Dr. K. A. Hirsch, and that of professor of zoology on Dr. G. E. Newell, in respect of their posts at Queen Mary College. The following University appointments have also been made: Mr. A. Stuart, to the readership in statistics tenable at the London School of Economics and Political Science; and Dr. E. Cotchin, to the readership in veterinary pathology at the Royal Veterinary College.

Announcements

The Société Mycologique de France and the British Mycological Society are holding a joint foray at Reading during September 3–10. Further information can be obtained from Dr. F. B. Hora, The University, Reading, Berks.

A symposium on "Salinity Problems in the Arid Zones", organized by Unesco, will be held in Teheran during October 11–15. Further information can be obtained from M. Batisse, Arid Zone Unit, Department of Natural Sciences, Unesco, 19 Avenue Kléber, Paris XVI^{e}.

The annual conference of Aslib will be held at the University of Nottingham during September 5–8. Members are requested to register not later than August 22. Further information can be obtained from Aslib, 3 Belgrave Square, London, S.W.1.

The Institute of Rural Life at Home and Overseas is holding a course of rural studies at the Essex Institute of Agriculture, Writtle, near Chelmsford, Essex, during August 31–September 13. Further information can be obtained from the Institute, 159 Bryanston Street, Marble Arch, London, W.1.

The inaugural general meeting of the Gas Chromatography Discussion Group and an informal symposium will be held in the Chemistry Department, University College, Gower Street, London, W.C.1, on September 23. Further information can be obtained from Dr. D. Ambrose, Chemical Research Laboratory, D.S.I.R., Teddington, Middlesex.

A general discussion on "Ions of the Transition Elements", organized by the Faraday Society, will be held in Dublin during September 9–11. There will be two sessions, devoted respectively to optical and magnetic properties, and to the energetics of complexes. It is hoped to circulate advance proofs of the papers to be read. Further information can be obtained from the Assistant Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

The twenty-seventh general meeting of the Society for General Microbiology will be held in the University of Liverpool on September 18 and 19. Those wishing to present papers, films or demonstrations should send the titles to Dr. B. W. Lacey not later than July 28. An informal meeting of those interested in animal viruses will be held on September 18. Further information can be obtained from Dr. B. W. Lacey, Department of Bacteriology, Westminster Medical School, London, S.W.1.

A Summer School, organized by the Universities Federation for Animal Welfare, is to be held at Culham College, Abingdon, Berkshire, during September 13–20. The programme will include lectures on various aspects of animal welfare, animal husbandry, humane technique in the laboratory, and related international problems. The fee, including full board, is £7, with a special reduced fee of £4 for students. All inquiries and applications to attend should be addressed to Miss M. P. Williams, Universities Federation for Animal Welfare, 7*a* Lamb's Conduit Passage, London, W.C.1.

SPECTROSCOPY OF SOLIDS

A CONFERENCE on the Spectroscopy of Solids, held by the Physical Society at the Royal Radar Establishment, Malvern, on May 28 and 29, brought together physicists from many parts of the world engaged in research in this field. Within the past two years, high-resolution infra-red spectroscopy has given a great deal of new information on various processes which lead to optical excitation of electrons from the valence to the conduction band in semi-conductors, and this in turn has led to a better knowledge of the band structure of silicon and germanium and also of a few of the intermetallic semi-conductors. In the opening paper of the conference, R. A. Smith discussed the various types of transition which take place in silicon and germanium, and, in particular, the part played by emission and absorption of phonons. The formation of exciton states was also discussed. These may be associated both with direct transitions in which the crystal momentum does not change, and in which no phonons are involved, and also with indirect transitions involving an appreciable change in crystal momentum and hence the emission or absorption of a phonon. Excitons associated with direct transitions give rise to a line absorption spectrum and those associated with indirect transitions to a band spectrum. Absorption due to both types of exciton formation was reported and discussed (see below).

High-resolution absorption spectra corresponding to indirect transitions in germanium, and obtained for a wide range of temperatures extending from 4° K., have previously been obtained for germanium by G. G. Macfarlane, T. P. McLean, J. E. Quarrington and V. Roberts, of the Royal Radar Establishment, showing absorption due to exciton formation. From these spectra, energies of the longitudinal and transverse acoustic phonons corresponding to the zone-edge in the $< 111 >$ directions, at which the minima in the conduction band occur, were obtained. These were found to be in good agreement with values obtained by B. N. Brockhouse and K. Iyengar from observations of neutron scattering. Similar measurements for silicon were now reported. From an analysis of these, the phonon energies for momentum values corresponding to the minima in the conduction band in the $< 100 >$ directions were obtained. Four types of phonon were observed having energies $k\theta$ with $\theta = 212°$, 670°, 1,050° and 1,420° K. These were interpreted as corresponding, respectively, to the transverse acoustic, longitudinal acoustic, longitudinal optical and transverse optical phonons. The fact that four phonons are observed and not three shows conclusively that the minima in the conduction band for silicon do not lie at the zone-edge as for germanium, since at the zone-edge the longitudinal acoustic and optical phonons have the same energy in the $< 100 >$ directions. It is estimated that for silicon the minima occur for a crystal momentum of about 0·8 times the value at the zone-edge. Accurate values for the forbidden energy gap in silicon, and for its variation with temperature, were also obtained from these measurements.

Fine structure in the recombination radiation of silicon was reported in a paper by J. R. Haynes, M. Lax and W. Flood, of the Bell Telephone Laboratories. This radiation was shown to be due to indirect transitions, and those corresponding to emission and absorption of all the four phonons discussed above were identified. Moreover, the phonon energies obtained in this way agree quite well with those obtained from the absorption spectra.

New measurements of the absorption due to the direct transition in germanium were also reported by Macfarlane, McLean, Quarrington and Roberts. These showed a strong line absorption due to the lowest exciton state. Owing to the effect of the Coulomb interaction between the free electron and hole, the form of the spectrum in the region of continuous absorption is considerably modified, and the variation with quantum energy $h\nu$ is not proportional to $(h\nu - \Delta E_0)^{\frac{1}{2}}$, as is frequently stated (ΔE_0 is the forbidden energy gap at the centre of the first Brillouin zone). The form of the continuous absorption spectrum was measured at high resolution and shown to be in very good agreement with that found theoretically on taking the Coulomb interaction of the free electron and hole into account. An accurate value for ΔE_0 is also obtained by this means.

In a theoretical paper on the phonon spectrum of germanium by F. Herman, of the Radio Corporation of America Laboratories, Princeton, forces including the effects of up to fifth nearest neighbours were taken into account. A comparison was made with the most recent observations by Brockhouse and Iyengar, using neutron scattering, of all four branches of the phonon spectrum of germanium.

The effect of strong magnetic fields on the absorption spectrum of germanium and other semi-conductors was described in papers by B. Lax and by S. Zwerdling, of the Lincoln Laboratory, Massachusetts Institute of Technology. Observation of the oscillatory magneto-absorption effect for direct transitions, due to quantization of electrons and holes into Landau levels in the magnetic field, previously reported by these authors, has been extended by use of higher spectral resolution to give the fine structure due to the degeneracy of the valence band of germanium. These observations enable the effective electron mass at the centre of the Brillouin zone to be determined. Magneto-absorption has now also been observed due to the indirect transitions involving emission and absorption of phonons. Observation of absorption in the direct transitions due to exciton formation was also reported; there was some indication of an excited state of the exciton. The variation of the position of the exciton absorption with magnetic field has also been studied.

Infra-red absorption due to impurities in semiconductors was discussed by E. Burstein, of the Naval Research Laboratory, Washington. Recent observations have shown that the excited states of impurities in p-type silicon do not give a hydrogen-like spectrum. This effect is due to the degeneracy of the valence band at the centre of the Brillouin zone. The same author also discussed absorption spectra due to lattice vibrations in polar and homopolar crystals. New observations, with increased resolution, of the lattice absorption spectra of silicon were reported by F. A. Johnson, of the Royal Radar Establishment. It is now possible to

interpret many of the absorption bands in terms of the phonon energies obtained from the indirect inter-band transitions. In most cases, two phonons are involved, but some of the weaker bands require three.

The optical properties of metals were discussed by F. Abeles, of the Institut d'Optique, Paris. Infra-red reflexion spectra have been studied with the view of obtaining information on the effective number of free electrons. Such observations for some of the noble metals and also for the alkali metals were discussed by M. H. Cohen, Cavendish Laboratory, Cambridge, who distinguished between thermal and optical effective masses and showed how the optical data may be used to determine whether the Fermi surface does or does not meet the boundaries of the first Brillouin zone.

Papers on a number of other materials were also presented, including diamond, quartz, and the compounds, InSb, CdTe and Bi_2Te_3. These were mainly concerned with observation of absorption and emission spectra. Such spectra have not yet been obtained with the same high resolution, or analysed in the same detail, as for silicon and germanium.

The conference was chosen as the occasion for the delivery of the forty-second Guthrie Lecture of the Physical Society, by Prof. W. E. Lamb, of the Clarendon Laboratory, Oxford, on "Experimental Tests of Quantum Electrodynamics".

During the conference an opportunity was available for delegates to visit the new Solid State Physics Laboratory at the Royal Radar Establishment. This was officially opened on the previous day, May 27, by the Right Hon. Aubrey Jones, Minister of Supply, together with a new laboratory for the study of guided missiles. The latter will be part of the laboratory facilities of the Guided Weapons Department under Dr. W. H. Penley. The Solid State Physics Laboratory will be included in the Physics Department under Dr. R. A. Smith. This Laboratory has been specially planned for research in the physics of solids and particular care has been taken to ensure very clean conditions. Complete air conditioning is not used throughout the Laboratory, but only in certain sections which are allocated to work in which minute quantities of certain impurities can have disastrous effects on experimental work. The new building also includes a small radiochemical laboratory and fairly extensive facilities for work at liquid-helium and liquid-hydrogen temperatures. Typical examples of the research work already beginning in the new building were demonstrated to those attending the conference. R. A. Smith

THE DIPLOMA IN TECHNOLOGY

MANY who are concerned with the relation of science to industry combine to welcome, as a great educational reform, the institution of courses for the new Diploma in Technology. Candidature is open to science students who have obtained the General Certificate of Education (Advanced Level) or a good Ordinary National Certificate. The courses are mainly held in the top dozen or so colleges of technology, and often on a residential basis. Thus, students from Kent, Cornwall and Cumberland often study together, as at Brunel College, London, and elsewhere.

But obviously, the institution of a number of quite new degree-level courses, in different subjects, takes a good deal of working out, and raises many educational and administrative problems. In order to thrash these out further, the Brunel Staff Association held a national conference on June 20, attended by 180 delegates, being mainly senior members from the colleges concerned. Delegates were welcomed by Dr. J. Topping, principal of the College and himself a member of the National Council for Technological Awards, and by Mr. L. H. Hancock and Mr. E. E. Robinson, the conference chairman and secretary.

The opening paper, by Dr. A. J. Richmond, of the Welsh College of Advanced Technology, Cardiff, outlined the history of this great new educational venture; and the second paper, by Mr. Gordon Smith, of Brunel College, dealt with the industrial training period. While university education is all very well, it often neglects much which the young industrial scientist needs. Consequently, it was decided in 1955 to institute these new four-year courses, and on the sandwich principle. Thus, each student spends alternate periods of six months (*a*) at college and (*b*) undergoing industrial training in approved firms. Many companies now cordially welcome the scheme. Already a large proportion of the sandwich students are industry-based, that is, paid by their firms throughout the year. But the courses are open equally to students direct from a sixth form, with two advanced level and three ordinary level passes in General Certificate of Education examinations. These receive local education authority awards. More than 700 first-year students enrolled during the present session, and more than 1,000 are expected in 1958–59. The Diploma in Technology has already been recognized as the equivalent of a degree by the Burnham Committee.

Several speakers stressed the overloaded nature of many traditional science courses, where the student is expected to memorize far too many points of detail. A more selective, rather than an encyclopædic, approach is required. This comment was heard from as far apart as Mr. T. E. Hall, of Liverpool, with regard to building and civil engineering, and from Dr. E. G. Cowley, of Brighton, with regard to chemistry at both college- and school-level. It is one of the great potential virtues of the Diploma in Technology courses that syllabuses can be completely re-designed from first principles, to cope with this among other points. Mr. H. S. Barlow, of South-East Essex Technical College, however, questioned whether all colleges were seizing these exciting new educational opportunities boldly enough.

Modern methods of teaching and examining were also discussed, together with the general liberalization of approach. It was noted that those who qualify after the four years with a Diploma in Technology will be as useful to their firms as the average graduate is after another year or two of industrial training.

Further particulars about the courses are available from the Secretary, National Council for Technological Awards, 9 Cavendish Square, London, W.1.

NEW NATURE RESERVES IN ENGLAND

THE Nature Conservancy has announced the establishment of five new nature reserves in England, at Hickling Broad, Norfolk; Bure Marshes, Norfolk; Thetford Heath, Suffolk; Weeting Heath, Norfolk; and Knocking Hoe, Bedfordshire.

Hickling Broad comprises about 700 acres of shallow water surrounded by extensive reed-beds, fen, alder-wood and grass marshes characteristic of the Norfolk Broads. The history of the Broad as a bird sanctuary goes back to about 1911, when the late Lord Lucas, having bought the Whiteslea half of the Broad, approached a Hampshire friend and neighbour, Col. J. D. Mills (father of the present owner), of the Hickling half, who willingly agreed to let his part of it to form the sanctuary. Jim Vincent was appointed keeper. After the death of Lord Lucas, the ownership of one half and the lease of the other passed to the late Lord Desborough, who maintained the sanctuary at considerable personal expense with Jim Vincent's invaluable help.

The newly created National Nature Reserve, which lies 10 miles north-west of Great Yarmouth and covers an area of about 1,204 acres, has been established under Nature Reserve agreements with the owners, the Norfolk Naturalists' Trust and Major J. M. Mills.

The aquatic plant *Naias marina*, found in Britain only in certain Broads, is abundant at Hickling, together with many other rare plants, which are found in the marsh communities. The rich flora also supports some notable insects, of which the most outstanding is the swallowtail butterfly. The bittern, which re-established itself as a British breeding species on the nearby Sutton Broad in 1911, has bred at Hickling again since 1912, and the marsh harrier, which was also virtually extinct as a breeding species, returned rather later. To-day, harriers, bearded tits and bitterns are flourishing, together with several species of ducks, waders and other interesting birds.

The coypu, a large South American rodent which is now widespread in the Broads area, was first recorded at Hickling in 1950. It eats large quantities of vegetation and has in places eliminated much of the lesser reedmace. The increase of open water by eating out and breaking up encroaching plant life seems, on balance, so far to have been beneficial.

Those accustomed to visit the area will find no change as regards access, and the declaration as a reserve will not in any way affect the use of the Broad for sailing and fishing. Applications to visit the adjoining sanctuary area and for permits to collect specimens of plants and animals should be sent to the Secretary, Norfolk Naturalists' Trust, The Assembly House, Theatre Street, Norwich. Inquiries regarding proposed researches should be addressed to the Regional Officer for East Anglia, The Nature Conservancy, Government Offices, Bishopgate, Norwich.

The problem of the evolution and future of the Norfolk Broads is of considerable scientific and economic interest. Recent research has shown that many Broads were man-made in the Middle Ages and has partly explained why so many have become unnavigable lately. The Nature Conservancy has been asked to make a long-term scientific investigation of this problem, but as, unfortunately, no money could be found for it a start has not yet been possible. In addition to money and specialist staff, experimental areas are essential on which the scientists can work. These have now been provided through the generous co-operation of the Norfolk Naturalists' Trust and Col. Harry Cator and Mr. John Cator, of Woodbastwick, who have entered into Nature Reserve agreements on 734 acres of marshes and small broads (stretching some 2 miles from Ranworth to Decoy Broad, on the right bank of the Bure), which now comprise the Bure Marshes Nature Reserve.

Ranworth and Cockshoot Broads were given in 1949 by Col. Cator to the Norfolk Naturalists' Trust, who, with the support of the Conservancy, will continue to manage these Broads and marshes. Management of the privately owned Woodbastwick area also remains in the hands of its owners, and there will be no change as regards use or access.

The Breckland of south-west Norfolk and north-west Suffolk is an area of sandy heaths of the greatest importance for research on plant and animal populations in arid conditions resulting from its semi-continental climate and conjunction of sandy and chalk soils. Agricultural reclamation, afforestation, defence needs and other development have made great inroads into the unspoilt Breckland during the past thirty years. Thetford Heath, Suffolk, which lies 2½ miles south-west of Thetford and covers 225 acres, has been protected by the Norfolk Naturalists' Trust since 1949, and this reserve is now being declared under an agreement with the Trust.

Breckland birds in special need of conservation are well represented, and the breeding species include stone curlew, woodlark, wheatear and ringed plover. Most of the typical Breckland plants are to be found on Thetford Heath, which has, however, a stony broken ground surface with an incomplete covering of vegetation over a considerable area. During the 1930's parallel stripes of heather were observed, but it was not until recent years that this was connected with collections of flints in long parallel lines—the stone stripes revealed after the removal of a small area of surface soil during the Second World War.

Applications to visit and for authority to collect specimens of animals and plants should be made to the Regional Officer for East Anglia, The Nature Conservancy, Bishopgate, Norwich.

Weeting Heath, Norfolk, which has a wide range of Breckland heath vegetation types and consequently a flora and fauna of considerable interest, was purchased and presented to the Norfolk Naturalists' Trust in 1941, and a further area was added in 1944. Weeting Heath lies west of Brandon and covers 338 acres.

Typical Breckland birds, such as stone curlews, woodlarks, wheatears and a few pairs of ringed plovers (which rarely breed so far inland), are to be found. In the mid-section there is a wide area of bracken, and the reserve is separated from afforested land on the west by a well-defined stretch of ancient earthworks known as the Devil's Dyke. The absence of the rabbit from Weeting during the past two years has enabled uncommon plants to flower which had

not been recorded there for many years. The northern section of Weeting Heath consists largely of chalky grassland forming a thick turf with pine trees scattered in groups. The more barren parts of the heath have yielded a very rare spider (*Oxyptila scabricula*), and another spider (*Philodromus collinus*) occurs only at two other places in Britain.

Applications for permits, which will be necessary for those who wish to visit the reserve, to undertake research and to collect specimens of animals or plants, should be addressed to the Regional Officer for East Anglia, The Nature Conservancy, Bishopgate, Norwich.

Knocking Hoe in Bedfordshire is a small relic of a particular type of close-grazed chalk downland turf, which is rapidly disappearing under the present system of land use in Britain. The turf is thought to be of very ancient origin, and has probably remained undisturbed by cultivation at least throughout historic times. There is a rich flora of low-growing chalk downland species. The reserve has been established under a Nature Reserve agreement with the owner, Mr. L. T. Franklin. It will continue to be used for sheep grazing, as this is considered to be the best way to preserve the present composition of the sward. Access to the reserve will be by permit only, of which only a very limited number will be issued. Applications can be made to the Regional Officer for the South-East, The Nature Conservancy, 19 Belgrave Square, London, S.W.1.

POPULATION STUDIES OF THE COMMON EARWIG

DURING the summer of 1956, there was a plague of the common earwig (*Forficula auricularia* Linn.) in the garden of 28 Yarborough Road, Lincoln. Traps were erected to catch the earwigs and large numbers were caught. P. F. Baker (*Trans. Lincolnshire Naturalists Union*, 14, No. 2; December 1957) made a study of the relative numbers of males and females in the population and of the percentage of the population consisting of the variety with large elliptical forceps, known as form *forcipata* Steph. Later, it was decided to investigate the distance moved by different individuals in the population; this was done by a marking experiment.

The final total of 337 males and 332 females showed that during August and September 1956, in the earwig colony studied, males and females were present in almost equal numbers.

The males were found to be the most variable: the commonest varieties being those in which one-half of the calipers differed markedly in curvature from the other. This was found in both typical and form *forcipata* males. Two specimens were caught which from their external appearance seemed to be gynandromorphs.

Previous work on population statistics had led to the belief that earwigs were migrating from one part of the garden to another and it was decided to assess the movements of separate individuals in the population. To investigate movement an evenly spaced network of traps was set up over the area so that each trap was about one yard from its immediate neighbours. Separate pots were labelled and all insects caught in any particular pot were marked on the elytra with oil paints of a colour characteristic of the pot.

To mark the insects during a period of relative quiescence—from general observations the earwig seemed to be active at night and inactive, or nearly so, during the daylight hours—an actograph was used. This relied on a displacement of equilibrium as the insect moves in a cage; a mark is registered on a drum. In this way the earwig was shown to be entirely nocturnal, commencing activity at dusk and continuing to dawn. For this reason removal of the insects from the traps was carried out in the daytime; these earwigs were then marked with oil paint and released at the base of the trap in which they were caught. The marking, to be recognizable, usually lasted for one retrapping only; other earwigs ate the oil paint off their fellows.

Recaptures of marked individuals made up 12 per cent of the whole.

The results showed small daily migrationary trends. In this case conditions were ideal and food was not scarce. It is known, however, that the common earwig will, under special environmental conditions or when food is scarce, migrate in thousands in search of new grounds.

DIRECTING YOUNG SALMON

RESEARCH on the methods of guiding young Pacific salmon while migrating downstream have recently been described by J. R. Brett and D. F. Alderdice (Fisheries Research Board of Canada. Bulletin No. 117: Research on Guiding Young Salmon at Two British Columbia Field Stations. Pp. viii+75. Ottawa: Queen's Printer, 1958. 75 cents).

The first experiments, in 1953, were performed in a large divided trough using captive sockeye yearlings. These tests were intended to survey broadly the possibilities of using various techniques, including light, sound, air bubbles, curtains of hanging chain, odours, dye releases and differences in water velocity as means of guiding young fish. Significant deflexion resulted from the use of a relatively large area of illumination at night, a band of rising air bubbles or bursts of dark dye during the day, and strands of chain hung vertically during both day and night.

Further trough experiments, in 1954, on the use of hanging chain demonstrated that the maximum distance between strands which produced a deflexion of 75 per cent or more fish through an angle of 45° was 4 in. Apart from its light-reflecting quality, the type of chain was found to be unimportant. The sensory stimulus causing the avoiding reaction was found to be primarily visual. Slow oscillation of the chain increased the deflexion of sockeye. Coho yearlings were not significantly deflected.

In conjunction with the trough experiments, a limited number of field tests using a 56-ft. oscillating chain deflector (144 oscillations a minute) in the

Lakelse River, British Columbia, proved that the technique had promise for guiding a natural run of young sockeye. At right angles to the direction of water flow a maximum of 79 per cent deflexion was achieved. However, the barrier was subject to considerable penetration if conditions were not ideal; coho were still not effectively deflected.

A number of modifications was introduced in the 1955 deflector. The chain was replaced by cables which were suspended from a continuous moving belt. The belt travelled across-stream, reversing at the entrance to the trap. Various intervals and rates of travel (to a maximum of 12 in./sec.) were tested. The combinations which proved most effective included an interval between strands of not more than 6 in., and rates of travel from 8 to 12 in./sec. In these circumstances an average of 92 per cent of sockeye and 59 per cent of coho were deflected.

In addition to changes in the deflector, a new opening or by-pass to the inclined-screen trap was built. The particular features of the by-pass were a reduction of visual cues in the entrance by using smooth, painted surfaces, a gradual acceleration of the incoming water to a velocity equal to or just exceeding the maximum swimming speed of the migrants, and the presence of cross-reflecting mirrors. Although the first model had limitations, it improved the trapping of deflected fish and permitted a good numerical assessment of the deflector.

The final tests were conducted in Hoolnose Creek during the spring of 1956. Pink, chum and coho fry, as well as sockeye and coho yearlings, migrate down this small stream. The same deflector was used, with additional features of smaller, weighted cables, a minimum interval of 2 in. between strands, low direct-current charging of the moving cables, and a 3-ft. wide sheet of metal on the stream bed, painted white to reflect light incident on the surface. The reduction in spacing was introduced to scale down the interval dimensions to a more appropriate size for fry. Also, by adding an electric charge, a combination of stimuli was presented which was thought would be more effective.

No success was obtained in guiding any of the fry. However, both coho and sockeye fingerlings were deflected at 95 per cent level and higher.

The investigations showed that new methods must be sought for the guiding of salmon fry. For yearlings, a full-scale test is desirable under conditions which approximate to reservoir characteristics of large dams.

A NEW APPROACH TO THE CHEMOTHERAPY OF CANCER

By Dr. M. B. SAHASRABUDHE

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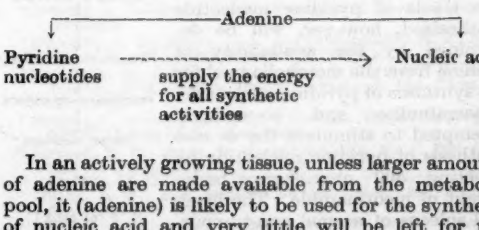
THE use of antimetabolites as a means of controlling cancer was first investigated by Sidney Farber[1] in 1948, using folic acid antagonists. Since then a number of compounds having antagonistic properties against such essential metabolites as purines[2], pyrimidines[3], vitamins[4] and glucose[5] have been tested. The main drawback of the antimetabolites tested so far has been that they interfered with the normal processes also, and as such exhibited toxic effects. Further, some of the tumours develop resistance to the drugs. The former difficulty might be overcome by using antimetabolites against a specific substance or substances having an important function in tumours only; but in spite of the large amount of work, such a qualitative difference between a tumour and normal tissue has not so far been discovered. There are, however, quantitative differences which might be exploited with advantage in the chemotherapy of cancer.

One of the striking differences between normal and malignant tissues is the active cell proliferation accompanied by high rate of synthesis of nucleic acid in neoplastic tissues. This high rate, however, is not a characteristic solely of neoplastic growth. Normal embryonic tissues are also known to exhibit active nucleic acid synthesis without any evidence of neoplastic transformations. Hence embryonic and tumour tissues are similar in so far as active cell proliferation and nucleic acid synthesis are concerned; but whereas embryonic growth comes to a stop after a while, the tumour continues to grow apparently without any control whatsoever. In the present communication an attempt is made to explain these differences in the light of existing knowledge, and to suggest ways and means of exploiting these differences to control cancer growth.

Regulation of Normal Growth by Biological Feed-Back Mechanism

To maintain the rapid rate of synthesis of nucleic acid, two things are essential: (i) a continuous flow of precursors and (ii) an unrestricted supply of energy. In the biological system, the energy is usually generated in the Krebs tricarboxylic acid cycle through the stepwise degradation of metabolites into carbon dioxide and water. Pyridine nucleotides have an important role in this connexion in the hydrogen transport system, and thus indirectly participate in the energy production via the tricarboxylic acid cycle. One of the precursors of pyridine nucleotides is adenine, which is also a precursor of nucleic acids. Since the same substance (adenine) is required for the synthesis of nucleic acid and also of pyridine nucleotide, a sort of chemical competition is set up between the two for appropriation of adenine.



In an actively growing tissue, unless larger amounts of adenine are made available from the metabolic pool, it (adenine) is likely to be used for the synthesis of nucleic acid and very little will be left for the synthesis of pyridine nucleotides. This seems to be corroborated by published work[6] on the levels of pyridine nucleotides in various tissues (see Table 1).

Table 1. Total Diphosphopyridine Nucleotides + Reduced Diphosphopyridine Nucleotide in the Liver of Adult, Embryonic, New-Born and Hepatectomized Rats
(Compiled after Jedeikin, Thomas and Weinhouse, ref. 6)

	Total DPN + DPNH	Percentage lowering in total pyridine nucleotides
Liver from adult rats	770 (731–819)	
Liver from 19–20 day fœtus	262	66
Liver of new born 1–3 hr. after birth	441	43
Liver of new born 1 day after birth	336	56
Liver of new born 7 days after birth	722	Values within normal range
Maternal liver of 19–20 days pregnant mother	550	28
Liver of mother 1 day post-partum	846	Values within normal range
Regenerated liver 3 days after hepatectomy	592	23
Hepatoma	250	78

Table 2. Pyridine Nucleotide Levels in Host Tissues (μgM./gm. Wet Tissues) of Tumour-Bearing Animals: Influence of Nicotinamide Administration on *in vivo* Stimulation of Synthesis of Pyridine Nucleotide
(Compiled after Narurkar, Kumta and Sahasrabudhe, ref. 7)

	Livers		Spleen		
	Control animals	Tumour-bearing animals	Control animals	Tumour-bearing animals	Tumour (fibro-sarcoma)
Initial	671	561	456	337	119
Levels of pyridine nucleotide after administration of 500 mgm./kgm. body wt. nicotinamide	3,063	1,334	2,900	892	611
Net synthesis of pyridine nucleotide in 12 hr.	2,393	773	2,444	535	492

It will be seen from Table 1 that active proliferation is invariably accompanied by lowering of the pyridine nucleotide levels. The figures for livers of mothers 19–20 days pregnant suggest that not only the adenine present in the fœtus is channelized for nucleic acid synthesis, but even that present in the metabolic pool of the mother is also drained, resulting in the depletion of pyridine nucleotide levels in the maternal livers of pregnant animals.

Sahasrabudhe and co-workers[7] have recently demonstrated that the pyridine nucleotide levels in the host tissues of tumour-bearing animals are considerably lower. Nicotinamide ribotide and adenine ribotide combine by a pyrophosphate bond to form a pyridine nucleotide molecule: nicotinamide–ribose–P–P–ribose–adenine. Kaplan[8] has shown that when nicotinamide is administered, pyridine nucleotide synthesis can be artificially boosted. The levels of pyridine nucleotide synthesized, however, will be determined by the availability of adenine from the metabolic pool for the synthesis of pyridine nucleotide. Sahasrabudhe and co-workers[7] attempted to stimulate the *in vivo* synthesis of pyridine nucleotide by injecting 500 mgm./kgm. body-weight of nicotinamide. The livers and spleens of normal non-tumour-bearing animals showed a net synthesis of 2,393 and 2,444 μgm. of pyridine nucleotide. The net synthesis in the liver, spleen and tumour of tumour-bearing animals, however, was only 773, 553 and 492 μgm.; that is, less than a third of that in tissues of normal animals (Table 2). This clearly suggests the unavailability of adenine for the synthesis of pyridine nucleotide in tumour-bearing animals.

But this appropriation of adenine for nucleic acid synthesis and the depletion of pyridine nucleotide levels cannot go on indefinitely, because in absence of adequate levels of pyridine nucleotide, hydrogen transport and energy production cannot go on efficiently. Since nucleic acid synthesis requires energy, the appropriation of adenine will itself act as a self-regulatory feed-back mechanism by limiting the pyridine nucleotide levels. This, it is suggested, is the mechanism by which normal hyperplasia comes to a stop after a particular level of proliferation has been achieved. The fact that tumours continue to grow indefinitely, apparently without the self-regulating feed-back mechanism just described, suggests that the tumours find alternative ways of producing their own energy requirements, independent of pyridine nucleotide levels and the tricarboxylic acid cycle.

Run-Away Growth in Tumours: Tumour Autonomy in Energy Production

Until recently, the Embden–Meyerhof pathway was regarded as the sole prototype of glycolysis whereby glucose was metabolized through the formation of glucose-6-phosphate, fructose-6-phosphate, fructose-1-6-diphosphate and triose phosphate, etc., as shown in Fig. 1. It is only recently that growing evidence has been forthcoming through the researches of Warburg, Lipman and Dickens to suggest an alternative pathway of glycolysis known as the hexose–monophosphate shunt or oxidative pathway[9].

In the absence of adequate levels of pyridine nucleotide, as in actively growing tumour tissues, the operation of the tricarboxylic acid cycle and the production of adenosine triphosphate are impaired, which perhaps result in accumulation of lactic acid. In the hexose–monophosphate pathway, no adenosine triphosphate is required; instead, an obligatory oxidation occurs early in the reaction sequence. It has been shown that sedoheptulose-7-phosphate and erythrose-4-phosphate can either be converted to triose phosphate and thus meet the Embden–Meyerhof pathway, or these may alternatively be converted to fructose-6-phosphate and re-enter the hexose–monophosphate cyclic processes[9]. Repeated opera-

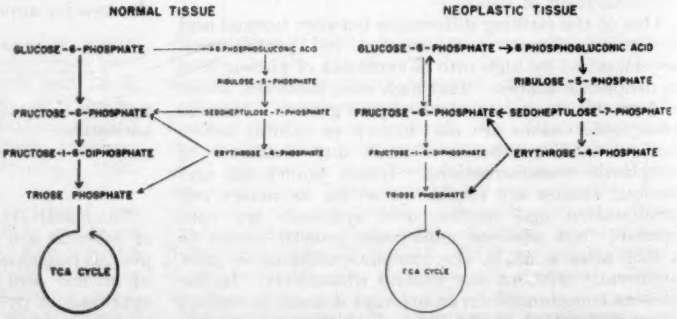


Fig. 1. Relative preponderance of Embden–Meyerhof and hexose-monophosphate pathways of glycolysis in normal and neoplastic tissues. Bold lettering and thick lines indicate the preponderance

tions of the hexose–monophosphate oxidative cycles yield carbon dioxide as the sole and final product, with the release of all the energy contained in the glucose molecule. How this energy is utilized is, however, not definitely known. It is perhaps a happy coincidence that the major portion of the ribose moiety, which is so essential for nucleic acid synthesis, is derived from the hexose–monophosphate pathway. It is felt that this is an example of efficient biological adaptation to get over the block in energy production and to get the most benefit with the least effort. Whatever be the correct explanation of this phenomenon, the cause and effect relationship appears to be very striking and calls for closer scrutiny. Whether any sustained and rapid synthesis of nucleic acid automatically accelerates the hexose–monophosphate pathway as an adaptive mechanism, or whether this is a characteristic of neoplastic transformations only, is at present under investigation and will be reported elsewhere.

Radioactive isotope technique has played a vital part in evaluating the relative rates at which the alternative pathways of glycolysis predominate in a given system. For this purpose samples of glucose labelled at the first or the sixth carbon atoms with carbon-14 have been used, and by determining the radioactivity in the carbon dioxide formed, one can evaluate the extent to which the two alternative glycolytic pathways are operative[10]. Using this technique, Van Vals, Bosch and Emmelot[11] have demonstrated the preponderance of the hexose–monophosphate oxidative pathway in a variety of tumours and their results are briefly summarized in Table 3.

Table 3. INCORPORATION OF RADIOACTIVITY IN CARBON DIOXIDE USING GLUCOSE-1-^{14}C AND GLUCOSE-6-^{14}C AS SUBSTRATES
(After Van Vals, Bosch and Emmelot, ref. 11)

	Ratio of $R6/R1$*	
	Without malonate	With malonate
Heart	1·05	0·42
Kidney	1·01	0·52
Brain	1·08	0·46
Spontaneous mammary carcinoma (*Dba*)	0·60	0·18
*T*5358: interstitial cell carcinoma testis	0·51	0·13
*UV*256 sarcoma	0·58	0·02
*T*26567 sarcomatoid ovarian tumour	0·72	0·25

$$*\frac{R6}{R1} = \frac{\text{Radioactive } CO_2 \text{ liberated using glucose-6-}^{14}C}{\text{Radioactive } CO_2 \text{ liberated using glucose-1-}^{14}C} = \frac{\text{(EM and TCA)}}{\text{(EM and TCA)} + \text{(HMP)}}$$

There is, however, one point which needs explanation. The two dehydrogenases in the early reaction sequence of the hexose–monophosphate pathway are dependent on the level of triphosphopyridine nucleotide. The question that naturally arises is how do these dehydrogenases function at higher levels when the levels of total pyridine nucleotide and triphosphopyridine nucleotide in particular are depleted. Glock and McLean[12] have examined this point closely and have found high values of dehydrogenase activity with low levels of triphosphopyridine nucleotide. Either it means that the tumour dehydrogenases are not dependent on triphosphopyridine nucleotide or that some other substance such as a specific dinucleotide acts as a hydrogen carrier in place of it.

Summarizing, therefore, it is suggested that the high rate of synthesis of nucleic acids in malignant transformations results in depletion of the levels of pyridine nucleotides and acceleration of the hexose–monophosphate pathway to obtain the energy required for proliferation. How low the level of pyridine nucleotides becomes will depend on how fast the synthesis of nucleic acid is going on. This concept of chemical competitions as the causative factor determining the levels of pyridine nucleotides, if true, might help in reconciling the divergent views held by Warburg[13] and Weinhouse[14] regarding the role of respiration in tumour tissue.

New Approach to Chemotherapy

It would appear from the foregoing discussion that the tumour derives its energy via the hexose–monophosphate pathway. It may be because of the independence of this pathway from normal regulatory feed-back mechanism that the tumour enjoys autonomy with regard to production of energy for its proliferation. Further, since the hexose–monophosphate pathway is not operative to a major extent in other normal tissues, any interference with that pathway might result in preferentially arresting the tumour growth only.

The possibilities and usefulness of preparing antimetabolites against glucose-6-phosphate, 6-phosphogluconic acid, ribulose-5-phosphate, etc., have therefore been considered. Since glucose-6-phosphate takes part in the Embden–Meyerhof as well as in the hexose–monophosphate pathway, use of its antimetabolites would exhibit toxic effects due to blockage of the Embden–Meyerhof pathway in normal tissues. Similarly, ribose is a constituent of a number of essential cofactors such as diphosphopyridine nucleotide, co-enzyme A, etc., which are necessary for normal body processes. Any substance, therefore, which interferes with ribose utilization would interfere with normal processes also and might prove toxic. Analogues of 6-phosphogluconic acid, however, appear to be free from any such objections. Work is at present in progress in this laboratory along these lines, and the preliminary results so far obtained with experimental chemotherapy of cancer with some of the compounds specially synthesized for the purpose are very encouraging. Details of this work will be published elsewhere.

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DISTRIBUTION OF PELAGIC POLYCHÆTES IN THE SOUTH ATLANTIC OCEAN

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IT has been established that the major hydrological boundaries in the South Atlantic Ocean restrict the distribution of many species of zooplankton[1]. Examination of pelagic polychætes collected by the "Discovery" Committee, between the ice edge (in 70° S.) and the equator, demonstrates for the first time that many of these have a significant distribution in relation to the sub-tropical and antarctic convergences. Minor hydrological boundaries affect the dispersal of particular populations and a correlation has been found to exist between the distribution of species and the movements of water masses.

Three pelagic polychætes do not occur north of the antarctic convergence and are endemic to the antarctic zone; they are *Rhynchonerella bongraini*, *Vanadis antarctica* and *Tomopteris carpenteri*. In the Atlantic sector *R. bongraini* has been found only in the top 500 m. of water in the antarctic zone within Weddell Sea water, the east wind drift, and in the upper layers of the warm deep water. *V. antarctica* probably occurs in all explored water masses in the antarctic zone; it is similar morphologically to *Vanadis longissima*, from farther north, and they may represent geographical races of one species. *Tomopteris carpenteri* was found, as adult, in all explored water masses of the antarctic zone; the smallest specimens of this species were, however, collected around South Georgia only, which suggests it may be a breeding area.

There seem to be no endemic sub-antarctic pelagic polychætes, *Vanadis longissima* being the only species (or geographical race of a species) with its southerly limit of distribution at the antarctic convergence; apart from occurring in the sub-antarctic zone it was collected only in the sub-tropical and tropical zones.

The following species have been found in the tropical and sub-tropical zones only; they appear to be limited in their southerly distribution by the sub-tropical convergence: *Tomopteris ligulata**, *T. krampi*, *T. elegans**, *T. apsteini**, *T. nisseni*, *Vanadis formosa**, *V. crystallina**, *Rhynchonerella angelini*, *Krohnia lepidota**, *Alciopa reynaudi**, *Naiades cantraini**, *Travisiopsis lobifera**, *T. lanceolata*, *Lopadorhynchus brevis**, *L. uncinatus**, and *L. krohni**.

It is noteworthy that twelve of these species (marked with an asterisk) are not known to occur in the North Atlantic Ocean to the north of the secondary polar front (as defined by Böhnecke[2]), which is a similar hydrological boundary to the sub-tropical convergence in the South Atlantic. These species appear to circulate in the Atlantic Ocean entirely between these boundaries.

The remaining species, *Tomopteris nisseni*, *T. krampi*, *Rhynchonerella angelini* and *Travisiopsis lanceolata*, range northward beyond the secondary polar front in the North Atlantic Ocean—in brief, this front is no barrier to them. No endemic pelagic polychætes are known from arctic waters, which implies that there is a constant influx of more southerly populations maintaining the homogeneity of the species over a wide area and preventing the evolution of endemic species. It is possible, therefore, that the endemic antarctic *Tomopteris carpenteri* may be represented in the arctic fauna by *T. nisseni* and *T. krampi*. Similarly, the endemic antarctic *Rhynchonerella bongraini* corresponds to *R. angelini*. Likewise, although the genus *Travisiopsis* is not represented by an endemic species in the antarctic zone, the species *T. coniceps* occurs only in southern waters and its corresponding species in arctic waters is *T. lanceolata*.

The following species were collected in all hydrological zones in the South Atlantic Ocean: *Tomopteris planktonis*, *T. septentrionalis*, *Typhloscolex mülleri*, *Travisiopsis levinseni* and *Pelagobia longicirrata*. Of these, *Tomopteris planktonis*, *T. septentrionalis* and *Travisiopsis levinseni* were collected in all explored water masses but never in regular abundance. *Typhloscolex mülleri* was collected in the antarctic zone in the warm deep water thoughout the year, migrating to depth in winter. A few records from the surface layers in summer suggest that at this season this species may also penetrate into Weddell Sea water. North of the antarctic convergence *T. mülleri* inhabits antarctic intermediate water, South Atlantic central water, and possibly also tropical surface water. *Pelagobia longicirrata* is the most abundant of all pelagic polychætes, and south of latitude 45° S. undergoes a migration to depth in winter. This species has been found in its greatest numbers in summer in the top 100 m. of water about the Greenwich meridian in the antarctic and sub-antarctic zones between the ice edge and 45° S. North of this latitude, to the sub-tropical convergence, it has not been found between 100 m. and the surface in samples so far examined. Böhnecke[2] has noted the presence of a boundary in this region which separates well-mixed water in the southern half of the sub-antarctic zone from more stably stratified water in the northern half; this boundary may segregate a southern population of *P. longicirrata* which inhabits these surface layers in summer (whether for feeding or for breeding purposes is not known). Elsewhere in the South Atlantic Ocean *P. longicirrata* has been collected in all explored water masses.

The distribution of species occurring at depth and limited in their range by surface hydrological boundaries may be explained by migration between water masses moving in opposite directions. Throughout the sub-tropical and tropical zones, species which do not occur south of the sub-tropical convergence could maintain their environment by migrating between southerly flowing South Atlantic central water, northerly flowing antarctic intermediate water and/or southerly flowing warm deep water. Surface currents throughout these zones set up an anti-clockwise circulation which would also restrict the southerly movement of the species.

It is probable that most cosmopolitan pelagic polychætes enter the antarctic and sub-antarctic zones in the southerly flowing warm deep water. By migrating upwards in the antarctic zone to antarctic surface water, and moving with this layer to its

conversion into northerly flowing antarctic intermediate water, circulation throughout the South Atlantic would be maintained. Within the antarctic zone a closed circulation, between antarctic surface water and warm deep water, is the simplest explanation of zonal movement, but endemic antarctic species, and antarctic populations of cosmopolitan species, are undoubtedly affected by much more complex circumpolar influences.

A full account of this study will be published elsewhere.

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RELATIONSHIP BETWEEN PHYTOALEXIN OUTPUT AND THE NUMBER OF INFECTIONS INVOLVED

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As previously reported[1], the germ tubes of *Phytophthora infestans* readily penetrate the epidermis of the seed cavities of *Phaseolus vulgaris*. The result of such penetrations is seen as necrotic lesions involving usually only one or two host cells, but the pathogen simultaneously ceases to grow and spread.

It was later shown[2] that the pathogen is checked by the antibiotic factor, phytoalexin, which results after infection from an interaction between the host tissue and the pathogen. In an attempt to study the relationship between the number of germ tubes penetrating into the host cells and the output of phytoalexin, experiments using known concentrations of zoospore suspensions were carried out along the following lines.

The pod cavities were inoculated with known volumes of zoospore suspensions varying in concentration from 8×10^2 to 10^4 zoospores per cm.^{3}. After incubation for 24 hr. at 20° C., the droplets were collected and the solutions thus obtained were tested in serial dilution by bio-assay with *Sclerotinia fructicola*[2], for their antibiotic activity. The latter was assessed by determining that dilution at which the length of the germ tubes was fifty per cent of that of the control. The reciprocal of this dilution was taken as the measure of activity in the undiluted solution or of the number of phytoalexin units per mm.^{3} of that solution. By definition, unit activity results from 1 phytoalexin unit per mm.^{3}, and this concentration will reduce the growth of germ tubes to one-half in the standard assay technique.

The number of cells directly affected by the pathogen was determined by removing the inoculated epidermal layers from the treated cavities after the inoculation drops had been collected, and by placing them in a 10 p.p.m. rhodamine *B* solution. After 3 hr. these layers were examined microscopically. The invaded and one or more adjoining cells showed staining. The figures in Table 1 refer to the number of penetrations per mm.^{2} of inoculated area.

The results tabulated are the averages for four experiments. It can be seen that there is no correlation between the number of infections (or penetrations) and phytoalexin output per mm.^{2} of inoculated host tissue. Only when the suspension was so diluted as to reduce the number of zoospores per mm.^{2} to less than 1 was an effective decrease in phytoalexin activity recorded.

It is pertinent to calculate the theoretical output of phytoalexin per mm.^{2} of inoculated epidermal tissue, on the assumption that ultimately there is the same concentration of phytoalexin in the bulk diffusate as in the affected cells. The calculation is also based on the assumption that the whole of the cell volume participates in the production of phytoalexin, and that no phytoalexin is inactivated by zoospores in the bulk diffusate. Any appropriate corrections would, however, increase the theoretical concentration of phytoalexin. The result of such a calculation is shown in the second row of Table 1.

The third row in Table 1 gives the calculated output of phytoalexin per mm.^{2} of affected cells. These figures are extremely high when one considers that 5–6 units of phytoalexin per mm.^{3} of water will completely inhibit hyphal growth *in vitro*. Thus when there are 56 penetrations per mm.^{2} of epidermal tissue the output of phytoalexin is more than 350 times that necessary to inhibit completely hyphal

Table 1. Number of Penetrations per mm.^{2} of Inoculated Area and Output of Phytoalexin

	Number of infections/mm.^{2} inoculated area								
	56	27	18	12	7	3	3	2	0·5
(1) Phytoalexin concentration in activity units in bulk diffusate	5·0	4·3	6·7	5·0	5·0	5·0	2·4	3·4	< 0·5
(2) Phytoalexin act. units produced/mm.^{2} epidermal tissue*	237	202	315	237	237	237	113	160	< 23·5
(3) Phytoalexin act. units produced/mm.^{2} affected tissue*	$2{\cdot}16 \times 10^3$	$3{\cdot}85 \times 10^3$	$9{\cdot}01 \times 10^3$	$1{\cdot}01 \times 10^4$	$1{\cdot}73 \times 10^4$	$4{\cdot}04 \times 10^4$	$1{\cdot}94 \times 10^4$	$4{\cdot}12 \times 10^4$	$< 2{\cdot}42 \times 10^4$

* Calculated from figures of row 1, in using the following data and formulæ:

Mean vol. liquid recovered from a single inoculated area = 9·2 mm.^{3}
Mean single epidermal area covered by the inoculum = 8·45 mm.^{2}
Mean depth of the epidermis = 23μ
Mean vol. of an individual epidermal cell = 28,100μ^3
Mean number of cells affected per point of penetration = 1·6

$$\text{Phytoalexin produced/mm.}^2 \text{ epidermal tissue inoculated} = \frac{\text{Phytoalexin conc.} \times 0{\cdot}2}{8{\cdot}45 \times 0{\cdot}023}$$

$$\text{Phytoalexin produced/mm.}^2 \text{ tissue infected} = \frac{\text{Phytoalexin conc.} \times 9{\cdot}2 \times 10^9}{\text{Infections/mm.}^2 \times 8{\cdot}45 \times 28{,}100 \times 1{\cdot}6}$$

growth at the site of infection; when there are 2 penetrations per mm.[2] the output of phytoalexin is some 7,000 times more than that necessary.

The conclusions that (1) the output of phytoalexin is excessively high per unit volume of affected cells, and (2) the output of phytoalexin is essentially constant per unit area of inoculated area suggest that not only the invaded cells but also the rest of the tissue adjacent to the inoculated face participates in the formation and liberation of phytoalexin. If so, it must be assumed that a factor diffuses into the inoculation drop which induces the non-infected cells to produce the inhibitory substance in their turn. In view of the fact that measurements of conductance in tissues interacting with the pathogen in a supra-sensitive fashion showed evidence of effect in advance of the pathogen[3], the above suggestion need not be considered too speculative. Also, the recent findings of Millerd and Scott[4], who separated a chemical factor from barley leaves infected with *Erysiphe graminis* which increases the respiratory rate in uninfected leaves, fit in with this hypothesis.

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STEREOCHEMISTRY OF COMPLEX HALIDES OF THE TRANSITION METALS

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THE ligand (crystal) field theory, originally developed by Bethe[1] and Van Vleck[2], has been used extensively since 1951 for the interpretation of the spectra of transition metal complexes[3]. It had been employed earlier to explain the magnetic properties of compounds of the transition[4] and rare earth metals[5], and, more recently, those of the actinide metals[6]. It has also proved very valuable in providing an increased understanding of the stereochemistry of transition metal complexes[7,8].

The ligand field theory considers the effect of the electrostatic field due to the ligands on the energy of the non-bonding *d*-shell of the central metal atom and assumes that the arrangement of the ligands about the metal atom is determined primarily by this non-bonding *d*-shell. The successes of the ligand field theory suggest that in many molecules and complex ions the dominating energy terms are indeed those related to electrostatic effects on the inner non-bonding *d*-electrons. We wish to direct attention in this article to cases in which this is not true, and in doing so to delineate more precisely the value of ligand field and other theories in the prediction and interpretation of the stereochemistry of transition metal complexes. While recognizing the validity of the energy effects calculated by ligand field theory, we believe that other factors such as the stabilizing energy of the directed σ-bond, the principle of electroneutrality of the metal ion[9], the polarizability of the ligand, the possibility of π-bonding between metal and ligand and the steric effects which result from interaction between ligands, are potentially important as structure determinants. We suggest that sometimes these may overcome ligand field effects and give rise to co-ordination shapes different from those expected from simple ligand field theory. First, we regard the principle of electroneutrality as of major significance in deciding the co-ordination number of the metal ion, for a knowledge of this must precede discussion of stereochemistry. In general, the preferred co-ordination number of a metal ion increases with its valency, and Pauling[9] has suggested that, as a rough rule, the co-ordination number is twice the valency. It is well known, however, that two or more co-ordination numbers may occur for the same metal ion; for example, $[FeF_6]^{3-}$ and $[FeCl_4]^-$. We consider that this arises not so much from steric effects as from differences in the polarizability of the various ligands and consequent transfer of charge to the metal ion through the σ-bond. For example, Fe^{3+} takes up ligands until its effective charge is reduced to nearly zero; it will require a greater number of F^--ligands to achieve this than Cl^--ligands, because there is greater electron transfer from each Cl^- to Fe^{3+} than from each F^-. Another example of this is the comparison of $[Co(H_2O)_4]^{2+}$ with $[CoCl_4]^{2-}$; the co-ordination number decreases as we pass from the less easily polarized H_2O to the more readily polarized Cl^- ligand.

Before discussing the shapes of complexes of metals the atoms of which have a non-spherical electronic shell, it is helpful to summarize the shapes expected for ions which have perfect spherical symmetry. As discussed elsewhere[8], the stereochemistry of complexes of non-transition metals can be generalized in terms of repulsions between *bonds* (whether single, double or triple) and lone pairs of electrons in the valency shell. This follows the approach originally suggested by Sidgwick and Powell[10]. On this model, the shapes of CH_4, NH_3 and H_2O are all based upon the tetrahedral arrangement, there being a total of four (bonds + lone pairs) in each case. The steady fall in the $H-X-H$ angle in the above sequence is explained by assuming that the repulsion lone pair : lone pair > lone pair : bond pair > bond pair : bond pair[11]. One can extend this picture to those transition metals the non-bonding *d*-shells of which are spherically symmetrical, elements with configurations d^0, d^5 (spin-free) and d^{10}. For ions with these configurations the shapes of complex molecules having no lone pairs are expected to be linear, triangular planar, tetrahedral, trigonal bipyramidal, octahedral and pentagonal bipyramidal, according as the co-ordination number is 2, 3, 4, 5, 6 or 7.

To appreciate the stereochemistry of complex ions with other than 0, 5 or 10 non-bonding *d*-electrons, the shapes of *d*-orbitals and their effect on the arrangement of the ligands must be considered. The ligand field theory assumes a purely electrostatic model for the calculation of energy effects; for example, the ion $[CoCl_4]^{2-}$ is regarded as a Co^{2+} surrounded by four Cl^- at the corners of a regular tetrahedron. Referred to orthogonal axes, the five *d*-orbitals may be divided into two classes; one class, the d_γ-orbitals, have lobes of electron density along

Table 1. CRYSTAL FIELD STABILIZATION* AND STEREOCHEMISTRY EXPECTED ON LIGAND FIELD THEORY (ALL SPIN-FREE)

No. of d-electrons	0, 5 or 10	1 or 6	2 or 7	3 or 8	4 or 9
Element and valency	(0) Ca^{2+}, Sc^{3+} (5) Mn^{2+}, Fe^{3+} (10) Zn^{2+}	(1) Ti^{3+} (6) Fe^{2+}	(2) Ti^{2+}, V^{3+} (7) Co^{2+}	(3) V^{2+}, Cr^{3+} (8) Ni^{2+}	(4) Cr^{2+}, Mn^{3+} (9) Cu^{2+}
Crystal field stabilization for perfect tetrahedron	0	$0{\cdot}6\ \Delta^1 = 0{\cdot}27\ \Delta$	$1{\cdot}2\ \Delta^1 = 0{\cdot}53\ \Delta$	$0{\cdot}8\ \Delta^1 = 0{\cdot}36\ \Delta$	$0{\cdot}4\ \Delta^1 = 0{\cdot}18\ \Delta$
Crystal field stabilization for perfect octahedron	0	$0{\cdot}4\ \Delta$	$0{\cdot}8\ \Delta$	$1{\cdot}2\ \Delta$	$0{\cdot}6\ \Delta$
Preferred stereochemistry	For shapes see text	Octahedron (very slightly distorted)	Regular tetrahedron, *or* octahedron (very slightly distorted)	Regular octahedron	Square planar *or* tetragonal

* $\Delta^1 = 4/9\ \Delta$

the z-axis (d_{z^2}) and along the x- and y-axes ($d_{x^2-y^2}$). The second class, d_ε orbitals, have their lobes of electron density in between the x-, y- and z-axes. There are three d_ε orbitals (d_{xy}, d_{xz} and d_{yz}) in the xy-, xz- and yz-planes, respectively. In an octahedral complex, these two classes of orbitals have different energies, the d_γ-doublet being of higher energy than the degenerate d_ε triplet. The lobes of electron density in the d_γ-orbitals point *towards* the ligands and in the d_ε-orbitals they point *between* the ligands. The separation Δ, or 10 Dq, between these degenerate levels is a measure of the strength of the electrical field produced by the ligands[3]. This is shown in Fig. 1*a*. For a tetrahedral complex the d_ε- and d_γ-levels are inverted since it is the d_ε orbitals which now point towards the ligands. The energy-levels are shown in Fig. 1*b*. In all cases the ligands are regarded as negative point charges.

When comparing complex ions of the same shape but having different numbers of d-electrons, this splitting leads to certain stabilization. Consider an octahedral complex of a d^1-ion, for example, Ti^{3+}. If the single d-electron were to spend 1/5 of its time in each of the five d-orbitals, its energy would be given by the point A. However, in fact, it is located in the d_ε-orbitals and the complex is more stable than the above hypothetical mean by an amount 4 Dq. This is the crystal field stabilization energy. For a tetrahedral complex, the value of Δ^1 is only 4/9 of Δ, and crystal field stabilization energies are consequently smaller for these complexes. Table 1 gives theoretical values for these crystal field stabilization energies.

We must take into account this effect in addition to the interactions between bonding pairs of electrons (σ-pairs) discussed earlier for spherically symmetrical metal ions. One expects to obtain a regular tetrahedron with the configurations d^0, d^5, d^5 (spin-free), d^7 (spin-free) and d^{10}, that is, when d_ε- and d_γ-shells

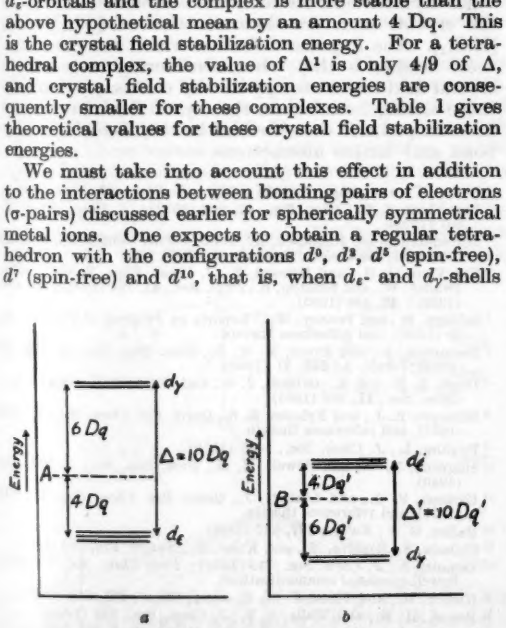

Fig. 1. Splitting of orbital levels in (*a*) octahedral complex; (*b*) tetrahedral complex, $\Delta^1 = 4/9\ \Delta$

in Fig. 1*b* are empty, half full or full. Tetragonal or square planar arrangements are expected for d^4 (spin-free) and d^9 configurations. Finally, all spin-free configurations except d^4 and d^9 should also give rise to a perfect or very slightly distorted octahedron. From ligand field theory the tetrahedral arrangement is expected to occur less frequently than the octahedral, since the crystal field stabilization energy is always larger in the latter case. These values are sometimes used as a means of assessing the relative ease of obtaining tetrahedral *vis-à-vis* octahedral complexes. However, we consider that there are so many other factors influencing the question that the value of crystal field stabilization energies for this purpose is limited.

We note that Orgel[3] has pointed out that, although crystal field splittings appear to be the important factors determining the relative stabilities of the tetrahedral and octahedral configurations, nevertheless these qualitative arguments may well prove deceptive; and he stressed the need for further testing of the theory.

First, even when using the purely electrostatic model, it needs to be emphasized that the energy required to assemble the field-producing arrangement is not the same. In other words, the positions A and B in Fig. 1 do not represent the same energy, and, indeed, the difference between these could be of even greater significance than the crystal field stabilization energy which is measured relative to these points. Secondly, these calculations ignore repulsions between ligands, and the fact that metal-ligand bond distances in octahedral and tetrahedral complexes are not usually the same.

The theory suggests that for electronic configurations other than d^3, d^5, d^5, d^7, d^{10} and also spin-paired d^4, a regular tetrahedral arrangement is much less probable than an octahedral, tetragonal or square planar one. Thus four-covalent spin-free Ni^{II} (d^8) and Fe^{II} (d^6) complexes are not expected to occur in a regular tetrahedral arrangement; but rather, if they occur at all, in a grossly distorted tetrahedron. There has long been speculation concerning the existence of tetrahedral Ni^{II} complexes. The usually accepted example, Ni^{II} *bis*-acetyl acetone[12,13], is now known to be a trimer almost certainly involving octahedrally co-ordinated nickel. Recently, however, Venanzi[14] has reported that complexes of the type $NiCl_2.2Ph_3P$ are monomeric in benzene, and hence the nickel atom is four-covalent; X-ray studies by Venanzi and Powell indicate that it is at the centre of a distorted tetrahedron[14]. This result is supported by the magnetic moment (3·1 B.M.), which is only slightly in excess of the spin-only value, 2·83 B.M., the orbital contribution being small. The latter should be large if the Ni^{II} is surrounded by a regular tetrahedron of negative charges. This arises because,

Table 2. Arsonium Tetrachloro Complexes of Transition Metals
General formula $[Ph_3MeAs]_2[MCl_4]$

Property	Metal Mn^{II}	Fe^{II}	Co^{II}	Ni^{II}*	Cu^{II}	Zn^{II}
Colour	Pale green	Cream	Blue	Green blue	Yellow	White
Conductivity in $PhNO_2$ in r.o. (conc. ~ $M/2,000$) (20° C.)	57·0	Oxidizes	55·0	55·8	60·4	53·2
Magnetic moment at 20° C. (B.M.)	5·88	5·33	4·69	3·89	1·91	Diamag.

* The corresponding iodides of Mn^{II}, Fe^{II}, Co^{II} and Ni^{II}, for example, $[Ph_3MeAs]_2[NiI_4]$, have been prepared and are isomorphous. The nickel complex is red and again has a high magnetic moment (3·49 B.M.). With the tetraethylammonium cation similar behaviour is observed, the magnetic moments of $[Et_4N]_2[NiCl_4]$ and $[Et_4N]_2[NiBr_4]$ being in the range 3·8–3·9 B.M.

Table 3. Predicted Magnetic Moments for Spin-free Bivalent Nickel Compounds

Environment of Ni^{II} atom	$\mu_{eff.}$ (calculated)
(1) Free Ni^{++} ion ($^3F_4$). No electrical field. $S = 1$, $L = 3$ (assuming $\lambda\nu = 0$)	4·47 B.M.
(2) As in (1) but using accepted value of $\nu = 2,347$ cm.$^{-1}$	5·56 B.M.
(3) As in (1) but assuming $\lambda\nu = \infty$	5·59 B.M.
(4) Ni^{2+} ion in octahedral ligand field assuming no spin-orbital coupling	2·83 B.M.
(5) Octahedral Ni^{II}, for example, $[Ni(H_2O)_6]^{2+}$ or $[Ni(NH_3)_6]^{2+}$, using accepted value of spin-orbit coupling constant λ (varies from 200 to 324)	~ 3·1 – 3·2 B.M.
(6) Ni^{2+} ion in tetrahedral ligand field, assuming no spin–orbital coupling (taking $L = 1$)	3·16 B.M.
(7) As in (6), using the same value of λ as in the octahedral case but assuming that Δ is very large, that is, that the only configuration to be considered is $d_{\gamma}{}^4d_{\varepsilon}{}^4$	3·6 B.M.*

* We are indebted for this figure to Dr. B. N. Figgis, who also reports that if Δ is not large enough to preclude configuration interaction, then the moment may be as large as 4·2 B.M. (unpublished work).

in order to obtain a large orbital contribution to the magnetic moment, one must have the possibility of re-arrangement of electrons in d_{ε}-orbitals when a magnetic field is applied. Three degenerate d_{ε}-orbitals containing a total of four electrons, as occurs for the Ni^{II} atom in a regular tetrahedral complex, provides an ideal example of this. A probable example of tetrahedral Fe^{II} occurs in the compound[15] $FeI_2.2Ph_3P$.

We have recently been studying complexes of the type $M(hal)_2.2$ pyridine of those bivalent metals which should give rise to both regular tetrahedral and octahedral arrangements; for example, $Mn^{II}(d^5)$, $Co^{II}(d^7)$ and $Zn^{II}(d^{10})$. In this connexion we have prepared compounds of the type $[Ph_3CH_3As]_2^+M(hal)_4^{2-}$, where hal = Cl, Br and I. These are obtained readily by adding the arsonium halide to the metal halide in alcoholic solution. In addition to the tetrahalide complexes of the metals listed above, we have obtained those of Fe^{II}, Ni^{II} and Cu^{II}. These are listed in Table 2. The Mn^{II}, Co^{II} and Zn^{II} complexes have the properties expected for four-covalent tetrahedral anions. The compounds are electrolytes in nitrobenzene, with the conductance expected for bi-univalent electrolytes. Only in the case of the Co^{II} compound is the orbital contribution to the magnetic moment helpful in deciding stereochemistry. The tetrahedral structure of the $[CoCl_4]^{2-}$ ion has been established in the compounds Cs_3CoCl_5 (ref. 16) and Cs_2CoCl_4 (ref. 17), the magnetic moments of which are close to that observed for $[Ph_3MeAs]_2CoCl_4$. However, the magnetic moment of the Ni^{II} compound, 3·89 B.M., is unusually high; this points strongly to a tetrahedral arrangement of the ligands about the Ni^{II}. Moreover, for the orbital contribution to be so large, distortion from a regular tetrahedral arrangement is small. The expected magnetic moment for a tetrahedral Ni^{II} complex can only be calculated roughly owing to uncertainty as to the splitting, Δ, and the spin-orbit coupling constant. In Table 3 we list the calculated moments for Ni^{II} in various circumstances. The octahedral case has been carefully examined by Griffiths and Owen[18], who also emphasize that charge transfer between metal and ligand in metal hydrates occurs owing to weak σ-bonding.

The conclusion that these complex ions are tetrahedral is supported by X-ray diffraction investigations of single crystals of the compounds. With the exception of the Cu^{II} compound, which is expected to contain a tetragonal or square complex ion, the compounds of Mn^{II}, Fe^{II}, Co^{II}, Ni^{II}, and Zn^{II} are isomorphous, forming cubic crystals with cell edge 15·5 A. (Ni), space group $P2_13$, with four molecules in the unit cell. Though there are slight differences in cell constants, the intensities of corresponding diffraction maxima of the several compounds appear substantially the same, strongly indicating a regular tetrahedral arrangement for the Ni^{II} and Fe^{II} complexes, having accepted such arrangement for the Mn^{II}, Co^{II} and Zn^{II} complexes. Furthermore, the crystal symmetry is such that the metal atom lies on a three-fold axis, and taken in conjunction with the results of our other physical-chemical experiments, we conclude that it is surrounded by three equivalent chloride ions and one non-equivalent chloride ion also on the three-fold axis. The magnetic behaviour of $[Ph_4As]_2[NiCl_4]$ in a suitable non-co-ordinating solvent should prove of interest, because under these conditions the constraining effects, if any, of the lattice of neighbouring ions will be removed.

These investigations are being extended to include other bivalent and tervalent metals, and to complete the crystal structure determination of $[Ph_3MeAs]_2[NiCl_4]$. The important feature which emerges from these studies is that when considering cases where crystal field forces are opposed by others, particularly those arising from bonds, the crystal field forces may be swamped and the structure be that determined by bond and lattice interactions.

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SHEEP HÆMOGLOBINS

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Some Genetic and Physiological Aspects of Two Different Adult Hæmoglobins in Sheep

INVESTIGATING more than 4,500 sheep of different breeds, Harris and Warren *et al.*[1-3] described the presence of two electrophoretically different types of adult hæmoglobin. The hæmoglobin moving more rapidly towards the anode at *p*H 8·6 was called Hb-*A* and the slower migrating component Hb-*B*. The occurrence of the two sheep hæmoglobins appears to be genetically determined by two genes, each responsible for the formation of one type of hæmoglobin. Large differences in the relative frequencies of the two types of sheep hæmoglobin were found from breed to breed; the lowland breeds have predominantly the Hb-*B* type and the highland breeds the Hb-*A* type. Two types of adult hæmoglobin were also found in Dutch sheep (Texel breed)[4]. They are designated Hb-I (slow-moving in paper electrophoresis) and Hb-II (fast-moving hæmoglobin). It is not known whether these two types of hæmoglobin are identical with the hæmoglobins *B* and *A*, respectively, but the electrophoretic patterns are closely similar, and moreover, the Dutch breed is closely related to some English breeds, such as Leicester and Lincoln. Studying the physical and chemical properties of the two hæmoglobins[4], differences were found in their resistance to denaturation by alkali, in electrophoretic and chromatographic behaviour, in solubility in concentrated salt solutions and in amino-acid composition.

The incidence of the two types of hæmoglobin in 300 sheep of the Texel breed has been determined. 71 per cent of these animals had hæmoglobin of type Hb-I, 3 per cent Hb-II and 26 per cent both types. These values are of little importance, as the genetic pattern of one breeding ram strongly influences the gene frequencies in a herd.

Blood samples from 80 animals belonging to one pedigree were also examined. The results are given in Fig. 1. The first ram, used in 1954 and in 1955,

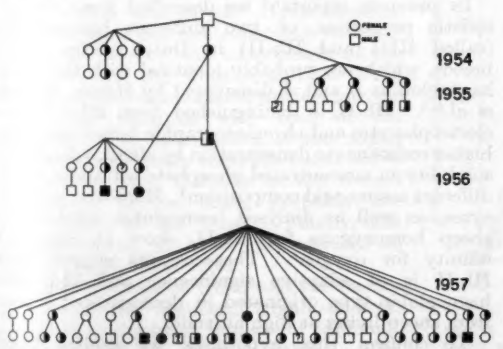

Fig. 1

Table 1. Genetic Pattern of the Two Sheep Hæmoglobins I and II
The values in parentheses indicate the expected numbers of lambs belonging to one of the three combinations

Male	Female		Lambs			
		No.	Total	I and I	I and II	II and II
I + I	I + II	13	18	7 (9)	11 (9)	
I + II	I + I	27	35	18 (17-18)	17 (17-18)	
I + II	I + II	10	12	3 (3)	4 (6)	5 (3)

was homozygous for Hb-I; three of the five ewes (year 1954) and four of the five ewes of 1955 were heterozygous for both hæmoglobins I and II. The gene responsible for the production of Hb-II was transmitted to about half their descendants. One of the male lambs, born in 1954 and heterozygous for Hb-I and II, was used as breeding-ram in 1956 and 1957. Many ewes being impregnated by this ram were heterozygous for the two hæmoglobins. So it was possible to get figures on the inheritance of both types of hæmoglobin. The results shown in Table 1 indicate that the two types of hæmoglobin are inherited in a simple Mendelian manner, resembling the genetic pattern of some types of human hæmoglobin.

During these investigations, it was observed that samples of venous blood (obtained by puncture of the vena saphena) of sheep homozygous for Hb-II seemed to be oxygenated to a greater extent than were the corresponding blood samples of sheep homozygous for Hb-I. Analyses of the oxygen saturation[5] of a few samples of venous blood showed values of 85, 87 and 90 per cent for the sheep homozygous for Hb-II, and 69, 72 and 75 per cent for the sheep homozygous for Hb-I. These preliminary results prompted us to study the oxygen affinities of the blood from the two types of sheep as well as of the hæmoglobins in solution. Small samples of blood (1·0 ml.) in a tonometer of 150 ml. capacity[6] were exposed to various gas mixtures containing known percentages of oxygen and a fixed percentage (40 mm. mercury) of carbon dioxide. Equilibration was obtained by rotation of the tonometer in a water-bath at 37° C. for 20 min. The percentage saturation with oxygen was measured spectrophotometrically[5], and the *p*H values of the samples were also determined. Hæmoglobin solutions were prepared by laking fresh, washed erythrocytes with an equal volume of distilled water and 0·4 vol. of toluene for 3 hr. at 2° C., followed by centrifugation at high speed in the cold for 30 min. Following the technique described by Allen *et al.*[7], both hæmoglobin solutions were dialysed for 16 hr. simultaneously against the same sample of 0·4 *M* phosphate buffer of *p*H 7·5, containing 1·0 *M* glucose. The oxygen affinities of these hæmoglobin solutions, containing hæmoglobin in a concentration varying between 14 and 17 gm. per 100 ml., were measured using the same method as described for the blood samples. Possible modifications of the oxygen saturation of the samples pro-

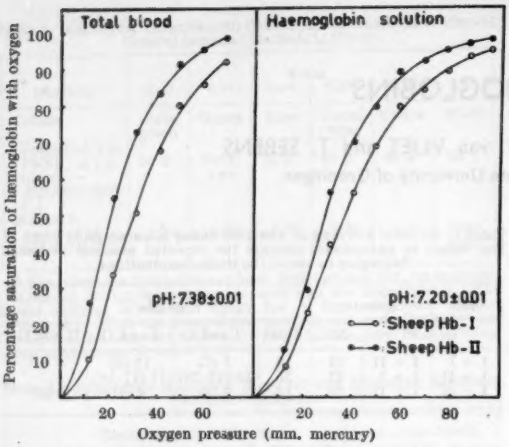

Fig. 2. Oxygen dissociation curves of the two sheep haemoglobins

duced by differences in the carbon dioxide tension of the blood and haemoglobin sample or by deviations in the *p*H could be excluded, since a constant carbon dioxide tension (40 mm. mercury) was applied and the *p*H values of the samples after equilibration varied only within narrow limits (± 0·01).

Fig. 2 illustrates the results. It was found that the oxygen dissociation curve of the blood obtained from a sheep homozygous for Hb-II was shifted to the left, indicating a higher oxygen affinity of blood of type Hb-II. This finding may be explained by intrinsic differences of the haemoglobin molecule rather than by differences in the environment of the haemoglobin, since the oxygen affinities of the dialysed solution of blood of type Hb-II were consistently higher than those of the corresponding dialysed solution of blood of type Hb-I. These results suggest that haemoglobin of type Hb-II has adaptive significance and may have originated by mutation in sheep living at high altitude. It is worth noticing that the frequency of haemoglobin of type Hb-*A* described by Evans *et al.*[3], which is probably identical with our Hb-II, is relatively high in the mountain and hill breeds, suggesting predominance of these animals by natural and human selection. This is remarkable, as any advantage in possessing this type of haemoglobin with increased oxygen affinity can scarcely be assumed at this moderate altitude.

The increased oxygen affinity allows the blood of a sheep of haemoglobin type Hb-II living at sea-level to take up more oxygen in the lungs, but also hampers the liberation of the oxygen from the blood in the tissues. So the oxygen, which is present in the blood, is less available to the tissues, resulting in an anoxia. Consequently, an increase of the total haemoglobin content of the blood may occur. Table 2 illustrates a significantly higher total haemoglobin content of the blood of the sheep of type Hb-II compared with the values found in sheep of type Hb-I. The values found in sheep heterozygous for both haemoglobins are intermediate.

Table 2. Total Haemoglobin Levels of the Blood of Lambs Two Months Old Possessing the Two Different Haemoglobins

Type	No.	Haemoglobin (gm. per 100 ml.)	*P*-value
Hb-I	70	11·7 ± 0·1	I to I/II < 0·01
Hb-I + Hb-II	25	12·2 ± 0·15	I to II < 0·001
Hb-II	4	13·2 ± 0·15	I/II to II < 0·01

The different oxygen affinities may also offer an explanation for deviations in the relative amounts of the two haemoglobins in sheep heterozygous for the Hb-I and Hb-II, when these animals are suffering from a severe anaemia, caused, for example, by chronic strongylosis and distomatosis. It was found (Table 3) that a decrease of the total haemoglobin content from 11 gm. per 100 ml. to 8 gm. per 100 ml. is compensated by an increased production of haemoglobin of type Hb-II, increasing the capacity of the blood for oxygen. When, however, the total haemoglobin content is decreased to very low values (2–4 gm. per 100 ml.), increased production of Hb-I occurs, which facilitates the liberation of oxygen from the blood to the tissues.

Table 3. Relation between the Total Amount of Haemoglobin and the Percentages of the Two Adult Haemoglobins in Sheep Heterozygous for both Types

Sheep	Total haemoglobin (gm. per cent)	Hb-I (per cent)	Hb-II (per cent)
A	11·2	56	44
B	8·4	36	64
C	4·2	70	30
D	1·8	76	24

It is evident from this work that the presence of two different types of haemoglobin in the adult sheep is a genetically controlled abnormality of haemoglobin synthesis. The increased oxygen affinity found for haemoglobin of type Hb-I may offer an explanation for its origination in sheep living at high altitude.

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Haemoglobin Types in Different Species of Sheep

In previous reports[1,2] we described some characteristic properties of two different haemoglobins (called Hb-I and Hb-II) in Dutch sheep (Texel breed), which are probably identical with the sheep haemoglobins *B* and *A* discovered by Harris, Warren *et al.*[3–5]. Hb-II is distinguished from Hb-I by its electrophoretic and chromatographic behaviour, by a higher resistance to denaturation by alkali, a decreased solubility in concentrated phosphate solutions, and a different amino-acid composition[1]. Moreover, erythrocytes, as well as dialysed haemoglobin solutions of sheep homozygous for Hb-II, show an increased affinity for oxygen[2]. These results suggest that Hb-II is of adaptive significance and that this haemoglobin-type originated in domesticated breeds from sheep living at high altitude.

To confirm this hypothesis we studied blood samples from some different species of sheep living

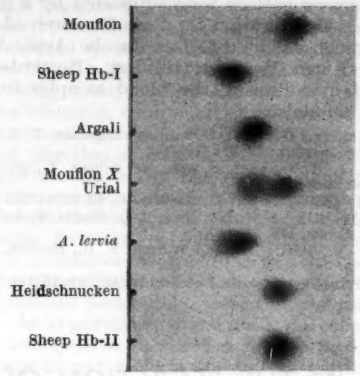

Fig. 1. Paper-electrophoretic separation of the hæmoglobins of different species of sheep

in the Zoological Gardens, Artis (Amsterdam) and Blijdorp (Rotterdam). We examined the following species of the genus *Ovis* : the Argali (*Ovis ammon*), living in the mountains of North and Central Asia above the timber-line ; the European Mouflon (*Ovis musimon*), originally living in South and Central Europe and at present in the mountains and forests of Corsica and Sardinia ; a cross-bred between the Mouflon and the Urial (*Ovis vignei*) and the Heidschnucken, a native breed of the Lüneburger Heide (Germany) which is most probably descended from the European Mouflon. One species of the genus *Ammotragus* (*A. lervia*), which lives in the mountains of North Africa, was also investigated. The hæmoglobins from one Argali, five Mouflons, one cross between the Mouflon and the Urial, four Heidschnucken and two *A. lervia* were examined by denaturation with alkali, by paper electrophoresis (0·06 *M* veronal buffer solution of *p*H 8·8) and by salting-out experiments. The oxygen dissociation curves of the total blood samples as well as of the hæmoglobin solutions were also established. The techniques used are described in previous papers[1,2].

The hæmoglobins of the different sheep showed the same high resistance to denaturation by alkali found for Hb-II, indicating that none of them is identical with Hb-I. The results of the paper-electrophoretic examination of the hæmoglobins are shown in Fig. 1. The hæmoglobins of the Mouflon and of the Heidschnucken show the same fast electrophoretic mobility found for Hb-II ; the hæmoglobin of the cross between the Mouflon and the Urial consists of two components, the fast moving one being identical with that of the Mouflon. The hæmoglobin of the Argali moves slightly faster than Hb-I and shows almost the same mobility as the second component of the cross, probably the hæmoglobin of the Urial. Finally, the hæmoglobin of *A. lervia* can scarcely be differentiated from Hb-I.

The solubilities of Hb-I, and the hæmoglobins of the Mouflon, Argali and *A. lervia* in phosphate buffers of different concentrations are given in Table 1. The hæmoglobin of the Mouflon and Hb-II show the same low solubility ; these hæmoglobins are completely insoluble in 2·8 *M* phosphate buffer. The solubilities of the hæmoglobins of the Argali and of *A. lervia* are intermediate between those of Hb-I and Hb-II, but they are not identical.

Table 1. Solubility as percentage in solution of Sheep Hæmoglobins in Phosphate Buffers (*p*H 6·5) of different Molarities

Species	2·10 *M*	2·59 *M*	2·80 *M*	2·94 *M*
Dutch Sheep Hb-I	100	100	90·5	24·0
Dutch sheep Hb-II	100	39·3	0·2	0
Mouflon	100	48·5	3·5	0·1
Argali	100	92·1	10·9	0·1
A. lervia	100	96·2	24·6	20·3

The oxygen dissociation curves of the total blood samples and of the dialysed hæmoglobin solutions are shown in Fig. 2. The oxygen affinities of the blood of the Mouflon and of the Heidschnucken are identical with that of sheep homozygous for Hb-II. The oxygen affinity of the blood of the Argali is still greater, while the oxygen dissociation curve of the blood of *A. lervia* is intermediate between those of the blood derived from sheep homozygous for Hb-II and Hb-I. Similar results were obtained for dialysed hæmoglobin solutions, indicating that the differences in oxygen affinity are inherent in intrinsic differences of the hæmoglobin molecules rather than due to differences in their environment.

From these results it may be concluded that Hb-II in the breed 'Texel' originated in the (European) Mouflon, confirming the generally accepted opinion that Dutch sheep (and perhaps also English sheep) are partially descended from this animal[6]. The Heideschnucke also possesses Hb-II. In none of the species investigated was Hb-I present. This hæmoglobin in Dutch sheep may therefore have originated in other types, for example Lincoln and Leicester sheep, which possess Hb-I only (unpublished results). The descent of these sheep is unknown. The presence of Hb-I in these breeds may have been derived from an unknown species living at sea-level.

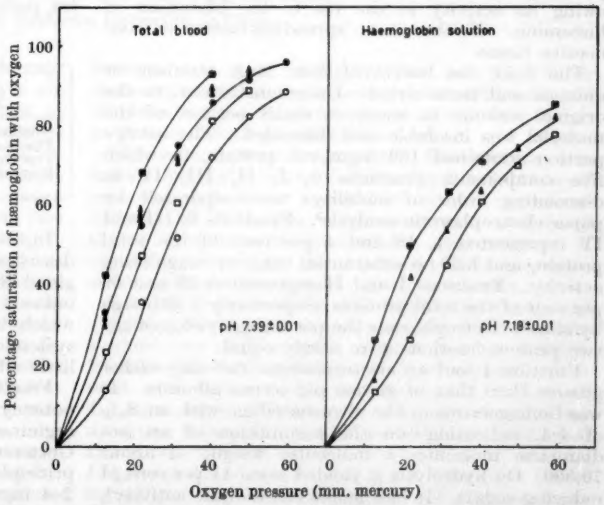

Fig. 2. Oxygen dissociation curves of blood samples of sheep : ○—○, Dutch sheep, breed 'Texel', homozygous for Hb-I ; ●—●, Dutch sheep, breed 'Texel', homozygous for Hb-II ; □—□ *A. lervia* ; ■—■, Argali ; △—△, Heidschnucken ; ▲—▲, Mouflon

It is remarkable that sheep living at high altitude (Argali) possess a hæmoglobin type with an oxygen affinity still greater than that of the Mouflon, while *A. lervia*, living at about 1,000 m. above sea-level, possess a hæmoglobin the oxygen dissociation curve of which is between those of Hb-II and Hb-I. It seems, therefore, that a specific type of hæmoglobin is present in these animals with its own chemical and physiological properties. Thus four different types of hæmoglobin can be demonstrated in sheep; in the genus *Ovis* besides Hb-I and Hb-II (identical with the hæmoglobin of the Mouflon) there is the hæmoglobin of the Argali, and in the genus *Ammotragus* the hæmoglobin of *A. lervia*.

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VASCULAR PERMEABILITY FACTORS IN THE SECRETION OF THE GUINEA PIG COAGULATING GLAND

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THE secretion of the coagulating gland of the male guinea pig induces a hypotensive shock on intravenous injection into the guinea pig and the rabbit, and œdema on local injection into the tissues[1].

The induction of œdema suggested that these effects were produced by substances increasing the permeability of the blood vessels. By preparative starch electrophoresis[2] in phosphate buffer at *p*H 8·0, we have isolated two main protein components (fractions I and II) from the fluid. Fraction I is hypotensive and a highly potent permeability factor in the guinea pig and rabbit; fraction II coagulates the contents of the seminal vesicles and is a moderately potent permeability factor in the rat and the rabbit, owing its activity in the rat to the liberation of histamine. Neither is a 'spreading-factor' in connective tissue.

The fluid was harvested from large numbers of animals and freeze-dried. On reconstitution to the original volume in water, a small portion of the material was insoluble and discarded. The soluble portion contained 150 mgm./ml. protein, in which five components (fractions 0, I, II, III, IV in descending order of mobility) were separated by paper electrophoretic analysis[3]. Fractions 0, III and IV represented 1, 10 and 4 per cent of the total protein, and had no substantial toxic or coagulating activity. Fractions I and II represented 16 and 69 per cent of the total proteins, respectively; although by starch electrophoresis the percentage yields of the two protein fractions were nearly equal.

Fraction I had an electrophoretic mobility rather greater than that of guinea pig serum albumin. It was homogeneous in the ultracentrifuge with an S_{20w} of 4·4, indicating—on the assumption of an isodiametric molecule—a molecular weight of about 70,000. On hydrolysis it yielded some 11 per cent of reducing sugars. It had feeble caseinolytic activity[4], about 1/5000 that of crystalline trypsin, disappearing on storage even at − 10° C., and contained a strong *p*-toluenesulphonylarginine methyl esterase[5], which had the same stability to heat as the permeability factor (losing only 20 per cent of its activity after 5 min. at 95° C.) and it was not antagonized by soya-bean trypsin inhibitor.

The permeability-increasing potency, measured in terms of blue exudation into the skin of animals with pontamine blue in their circulation, is expressed in Table 1 as the number of 'effective blueing doses'[6,7] per mgm. Fraction I is highly active in the guinea pig, and even more so in the rabbit; in both animals it was not inhibited by soya-bean trypsin inhibitor, and only slightly inhibited by mepyramine maleate and by the guinea pig serum fraction containing inhibitor of the serum permeability factor[8]; in the rat peritoneal cavity[10] it did not liberate histamine.

Table 1

Preparation	Effective blueing doses per mgm. in: Guinea pig	Rat	Rabbit
Original fluid (guinea pig)	20,000	1,100	200,000
Fraction I	50,000	50	600,000
Fraction II	500	1,300	4,000
Histamine (ref. 8)	32,000	1,400	37,000

Injected intravenously, it reproduced the effects described by Freund and Thompson[1] for the whole gland fluid; doses of 2–4 mgm./kgm. body-weight induced moderate shock in the guinea pig and rabbit, which in the guinea pig was slightly lessened by systemic mepyramine; whereas 16 mgm./kgm. had little effect in the rat.

Fraction II had three times the coagulating potency of the original fluid, but no caseinolytic or arginine esterase activity. The main observations of Gotterer and others[11] on the nature of the coagulating principle were confirmed. Intravenous doses of 2–4 mgm./kgm. were non-toxic to guinea pigs, and 4–7 mgm./kgm. were only slightly toxic to rabbits; but in rats 10–16 mgm./kgm. induced an effect like that of egg-white[12], including œdema of the snout.

In the rat, fraction II appears to owe its activity to the release of histamine, since its permeability effect was inhibited by mepyramine; and it liberated histamine in the rat peritoneal cavity[10], in this respect being about equipotent with the synthetic histamine liberator, compound 48/80 (ref. 13).

The increase in permeability induced by fraction II in the rat, like that of fraction I in the guinea pig and rabbit, was not affected by dialysis in 'Cellophane' sacs.

It is of interest that starch-block electrophoresis of the fluid from the *rat* coagulating gland yielded only two protein fractions, which had about the same respective mobilities as fractions I and II of the guinea pig fluid. Neither fraction was toxic to, nor had a significant permeability effect in, the three test animals. As in guinea pig gland fluid, the coagulating activity was present in the less mobile fraction II. The analogous status of rat and guinea pig fractions II is strengthened by the fact that each was capable of coagulating the seminal vesicular material from the other species.

Our results are consistent with the view that the main toxin, for guinea pig and rabbit, of fluid from the coagulating gland of the guinea pig is the permeability factor in fraction I, which appears to be a glycoprotein with arginine esterase activity. This toxin is in many important features unlike the globulin permeability factors in human[14] and other mammalian sera[7,9]. The permeability-increasing potency is negligible in the rat. On a weight basis, it is nearly twice that of histamine in the guinea pig; and in the rabbit it is outstanding among the potencies of all natural and synthetic permeability factors we have tested, being sixteen times that of histamine. On a molar basis, the protein of fraction I is, in these two animals, respectively 1,000 and 9,000 times as potent as histamine, suggesting an enzymic mode of action.

That fraction I is toxic for the homologous animal, particularly for the small blood-vessels, may be irrelevant to its function in the external glandular secretion of which it is a constituent; but its pharmacology may provide a clue to the mode of action of the enzyme-like, protein permeability factors present in blood and tissue fluids[15].

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SODIUM FLUOROACETATE AS A PROTECTING AGENT AGAINST IRRADIATION

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THE mortality as well as the somatic damage caused to living organisms by X- or γ-rays are greatly reduced by the previous administration of various compounds. To be effective, these substances must be injected into the animal immediately before irradiation. Cysteine, cysteamine and its derivatives were found to be most potent in this respect; many other compounds were also found to be effective (see refs. 1 and 2 for a review of the literature).

It now appears that deoxyribonuclease plays an important part in the destruction of deoxyribonucleic acid that follows irradiation. Deoxyribonucleic acid is localized in the cell nucleus, whereas acid deoxyribonuclease was found by de Duve *et al.*[3] to be concentrated in the small mitochondria, also called lysosomes. 'Neutral' deoxyribonuclease requires magnesium ions for its activity[4]. Therefore, it was thought that agents complexing magnesium ions would affect the activity of the enzyme and might protect against irradiation. Attempts to do so by intraperitoneal injections of large doses of sodium citrate (up to 1·25 gm./kgm.) to the mouse failed: very irregular results were obtained[5], presumably because injected citrate penetrates many tissue barriers with great difficulty (see ref. 6). Other chelating agents such as diethyldithiocarbamate and ethylenediamine tetraacetate, however, were found to protect mice against irradiation[7].

The administration of sodium fluoroacetate was known from the work of Peters and collaborators[8] (see also ref. 9) to accumulate citrate in animal tissues. The following experiments were performed to see whether the intracellular accumulation of citrate produced by the injection of fluoroacetate would protect the mouse against irradiation.

Lots of 10 mice of the *C57* black pure strain and weighing 18–22 gm. were given 750–775 r. at the average rate of 90 r./min., using a Siemens 200-kV. 'Stabilivolt'. Sodium fluoroacetate (Monsanto), when used, was injected intraperitoneally at a dose of 4–5 mgm./kgm. The toxicity of fluoroacetate for our mice was measured by the 'up-and-down' method of Dixon and Moore[10], as described by Kimball *et al.*[11]: LD_{50} was found to be 8·3 ± 1·4 (standard error) mgm./kgm. In our experiments, 4–5 mgm. sodium fluoroacetate/kgm. killed about 30 per cent of the control mice within 48 hr. To distinguish between that early death and death by irradiation which

occurs later, the number of surviving animals was expressed as a percentage of those which survived after the first two days.

If injected 5 hr. or even 2 hr. before irradiation, sodium fluoroacetate reduced the mortality produced by X-irradiations (see Fig. 1). After 7 days, 42 per cent of the irradiated mice had died, whereas mice pre-injected with sodium fluoroacetate were all alive; after 14 days, the mortality figures for the two groups were 90 and 20 per cent; after 21 days, 94 and 40 per cent. It will be seen in Fig. 1 that sodium fluoroacetate given just before or just after irradiations is without effect on the mortality, which reaches 47·5, 90·5 and 95 per cent after 1, 2 or 3 weeks. In other series, sodium fluoroacetate was injected 24 hr. before, or 5 hr. after, irradiation; no protection was observed in either case.

It is now believed that fluoroacetate is not toxic by itself but only after it has been transformed into fluorocitrate, a competitive inhibitor of aconitase, an enzyme of the tricarboxylic acid cycle (for a review, see ref. 12). Accumulation of citrate in the tissues of the rat follows after a latent period[13] of 30–60 min.; the highest level of citrate in the tissues of the rat was observed 2–8 hr. after the injection of non-lethal doses of the poison[13,14].

The curves of Fig. 2 show that the tissues of the mouse behave like the tissues of the rat: sodium fluoroacetate produces an accumulation of citrate (curve *A*) with a maximum 2–14 hr. after the injection of the poison. Irradiation 5 hr. after injection of sodium fluoroacetate (curve *B*) reduces the level of accumulated citrate, which returns to normal level within 24 hr., whereas 48 hr. are required in the case of non-irradiated mice. Irradiation alone (curve *C*) produces no measurable change in the citric acid content of the tissues. When the mice are irradiated immediately after injection of sodium fluoroacetate (curve *D*), accumulation of citrate seems to be somewhat delayed, at least in the kidneys; high levels are reached as in sodium fluoroacetate controls, followed by a more rapid return to normal.

Fairly similar results were observed in spleen and brain. In heart, however, the antagonizing effect of X-rays on the accumulation of citrate induced by sodium fluoroacetate was less noticeable; the disappearance of citric acid under the influence of X-rays was delayed in that radio-resistant organ.

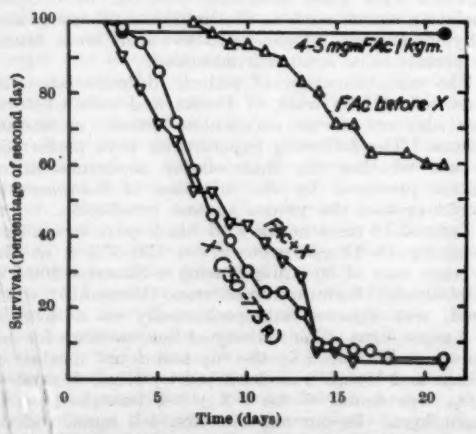

Fig. 1. Protection of the mouse against irradiation (*X*) by sodium fluoroacetate (*FAc*) injected 5 hr. before. The number of animals used in each experiment was: 4–5 mgm. *FAc*/kgm., 45; *X* (750–775 r.), 50; *FAc* before *X*, 40; *FAc* + *X* (simultaneously), 50

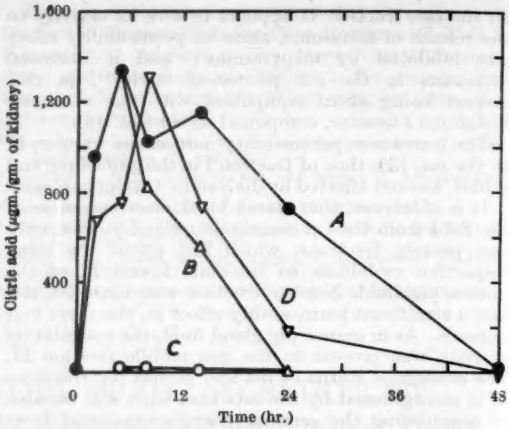

Fig. 2. Citric acid content of the mouse kidney. Curve *A*, sodium fluoroacetate only, 5 mgm./kgm.); curve *B*, 775 r. given 5 hr. after sodium fluoroacetate; curve *C*, 775 r. only; curve *D*, 775 r. given immediately after sodium fluoroacetate. Citric acid was estimated by the method of Taylor (ref. 16)

Our observations on the effects of sodium fluoroacetate and X-rays on the citric acid content of the tissues of the mouth are comparable to the results published by DuBois *et al.*[15], who demonstrated that rats, guinea pigs and mice receiving sodium fluoroacetate 3 hr. or more after irradiation accumulate less citrate than non-irradiated controls.

It may very well be that fluoroacetate somehow affects the sensitivity of the cells to X-rays by reducing their oxidative metabolism; many of the so-called radio-protectors are, in fact, toxic agents. Fluoroacetate may, however, protect the cells in a more specific way, accumulating citrate, complexing the intracellular magnesium ions, and so affecting the deoxyribonuclease activity, as we have supposed: such a mechanism, still very speculative indeed, is supported by the results of our experiments, although not proved, of course. If the availability of free magnesium ions must be reduced to afford radio-protection, it would seem from the evidence presented here that such a reduction must be completed at the very moment of the irradiation; sodium fluoroacetate injected only at that time piles up citrate too late, and no longer protects.

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LETTERS TO THE EDITORS

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A Revision of the Azulene Structure

In a previous communication from this laboratory[1], a crystal structure for azulene based on the non-centrosymmetric space group Pa was reported. It was assumed that the $(0k0)$ halving was accidental and it was easy to place the two molecules with respect to the glide plane in such a way that an almost exact halving of these spectra was obtained. This structure led to reasonably good agreements in all the principal zones, the discrepancies between observed and calculated structure factors being about 12 per cent for $(h0l)$, 14 per cent for $(hk0)$ and 20 per cent for $(0kl)$. A convincing electron density map for the projection on (010) was obtained, and it was confidently expected that a further analysis of the full three-dimensional crystal data would lead to a complete refinement of the structure, with significant values for the bond-lengths and electron distribution. Our preliminary structure was further supported by an independent investigation made by Takeuchi and Pepinsky[2], who obtained almost identical results. Neither of us saw any evidence of disorder in our X-ray photographs, although Günthard[3] has shown from a comparison of the entropies of azulene and naphthalene that there may be some disorder in the azulene crystal.

We now find that our preliminary structure is wrong, or at least it constitutes only half the truth, and the structure must in fact be disordered, as postulated by Günthard. This is one of the most remarkable examples that we have encountered of a preliminary structure based on data from three crystallographic zones being wrong in spite of quite reasonably good agreements in the structure factor calculations.

When we proceeded to refine the structure from our full three-dimensional data it was not long before we encountered difficulty. Various difference syntheses and generalized projections did not lead to much refinement, and after these had been carried out the average discrepancies between calculated and observed structure factors over all the 670 observed (hkl) reflexions was 23·4 per cent. With the help of Prof. Ray Pepinsky and Dr. V. Vand we then attempted a least squares refinement of the three-dimensional data, but after three cycles of such refinement the average discrepancy only decreased to 22·4 per cent.

Something was clearly wrong, so we next examined the possibility that the space group might after all be $P2_1/a$, as indicated by the halvings, and the structure really centrosymmetric. The atomic co-ordinates deduced previously were referred to a new origin at the centre of the molecule which was taken to coincide with a centre of symmetry in $P2_1/a$, and the atoms were given half-weight. This procedure postulates the superposition of two molecules in the previous orientation except for the inversion of the second molecule through the symmetry centre. Physically, and according to the chemical evidence, this must correspond to a simple random reversal of direction of successive azulene molecules in the crystal. A view of the resulting superposition of two molecules is shown in Fig. 1.

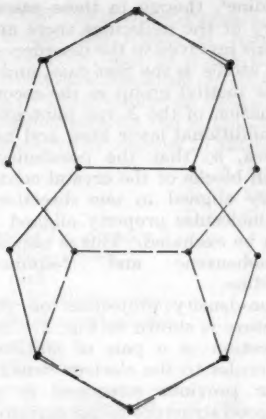

Fig. 1. Superposition of two azulene molecules

On this basis structure factors were calculated, and after some preliminary refinement they showed distinctly better agreement with the observed values than was the case with the non-centrosymmetric structure. Again with the help of Prof. Pepinsky and Dr. Vand eight cycles of least squares refinement were then applied on this new basis, and as a result the overall discrepancy dropped to 13·5 per cent. A comparison of the percentage discrepancies obtained for the two structures is shown in Table 1.

Table 1. Percentage Discrepancies obtained for Structures based on the Alternative Space Groups $P2_1/a$ and Pa

Space group	$(h0l)$	$(hk0)$	$(0kl)$	$(hkl$
$P2_1/a$	8·6	8·9	12·9	13·5
Pa	11·5	14·2	20·0	22·4

These figures establish definitely that azulene has a disordered structure as postulated earlier by Günthard[3]. This disorder is of the same type as found in *p*-chlorobromobenzene[4,5] and is also similar to that reported in the case of 2-amino-4-methyl-6-

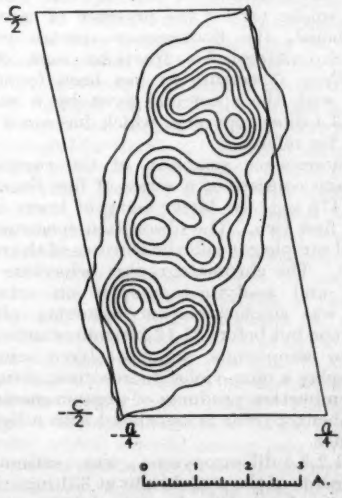

Fig. 2. Azulene. Electron-density projection on (010)

chloropyrimidine[6], though in these cases because of the symmetry of the molecules there are effectively only two atoms involved in the disorder—the chlorine and bromine atoms in the first case, and the chlorine atom and the methyl group in the second case.

An examination of the X-ray photographs showed no trace of additional layer lines and no diffuseness in the spectra, so that the possibility of a fault structure with blocks of the crystal containing molecules properly aligned in one direction and other blocks with molecules properly aligned in the other direction can be excluded. This is also the case with *p*-chlorobromobenzene and 2-amino-4-methyl-6-chloropyrimidine.

An electron-density projection on (010) for the revised structure is shown in Fig. 2. The similarity of this projection of a pair of statistically superimposed molecules to the electron-density projection given in our previous structure[1] is striking and explains the good structure-factor agreement obtained for that structure.

Because of the overlap of atoms the bond-lengths available from this study are of limited accuracy, but the central bond at 1·458 A. appears to be distinctly longer than the other bonds in the molecule. A more complete analysis of this structure will be described elsewhere.

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Presence of 1,2,3,4-Dibenzopyrene in Cigarette Smoke

In an investigation of the neutral fraction of cigarette smoke tar for the presence of carcinogenic hydrocarbons[1], the fluorescence spectra given by various chromatographic fractions were obtained. One of these (spectrum *h*) has been found to be identical with the spectrum given by a sample of pure 1,2,3,4-dibenzopyrene, which has since become available for reference.

The fluorescence spectrum of the compound in cyclohexane consists of a series of fine lines at 462, 470 and 478 mμ, the latter being of lower intensity than the first two. The absorption spectrum of the analytical sample gave all the features of the reference standard[2]. The chromatographic behaviour of both standard and analytical samples on columns of alumina was similar, elution occurring after 3,4-benzopyrene but before 11,12-benzofluoranthene. The latter two compounds, organic solvent solutions of which display a blue–violet fluorescence, occur widely in the combustion products of organic matter. The 1,2,3,4-dibenzopyrene is associated with a light green fluorescence.

The 1,2,3,4-dibenzopyrene was estimated by measurements of the peak height at 331 mμ. 1·6 μgm. was recovered per 100 cigarettes of average weight 1·1 gm., smoked to a stub length of about 1·5 cm. This is of the same order of concentration as that found for 3,4-benzopyrene.

Small quantities of 1,2,3,4-dibenzopyrene have been detected in petrol and the exhaust products of Diesel engines. It has not, however, been detected in a sample of general urban atmospheric soot, in marked contrast to 3,4-benzopyrene, which was found to occur there in a relatively high concentration[3]. Thus, it would appear that the urban-dwelling cigarette smoker has an exposure to 1,2,3,4-dibenzopyrene in a concentration not realized by his non-smoking neighbour.

As a result of preliminary tests, Bachmann *et al.*[4] and Cook and Kennaway[5] have described 1,2,3,4-dibenzopyrene as a carcinogenic agent of considerable potency.

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Radiometric Estimation of Unsaturated Fatty Acids on Chromatograms

A technique is desirable for estimating amounts of fatty acids separated by partition paper chromatography, without necessity for time-consuming elution, and free from inherent errors of strip photometry. Radiometric methods can meet these requirements, and in chromatographic applications have sometimes allowed accurate definition of spot geometry, which in some cases may be quantitatively related to spot content[1].

Kaufman[2] has determined the iodine number of unsaturated fats pipetted on to a paper support, using iodine-131 monobromide in absolute methanol. We have used iodine-131 to develop a method for quantitative estimation of unsaturated fatty acids separated by partition paper chromatography.

The acid mixture is revolved on 15 mm. × 280 mm. Schleicher and Schull 598 *L* paper strips, using a mixture of synthetic hydrocarbons of very low bromine number (0·16) and boiling point 180–190° C., called 'Mepasine' (Polish product, Ciech, Warsaw), as stationary phase, and 90 per cent acetic acid saturated with 'Mepasine' as mobile phase in ascending reversed-phase chromatography under nitrogen. 'Mepasine' is applied to the strips as a 20 per cent solution in freshly distilled ether free of peroxide, followed by evaporation of the ether.

The strip is dried after chromatography at 60° C. for 1 hr. in nitrogen. It is then immersed in 6·5 ml. of a solution of 0·0022 *M* sodium iodide, 0·0044 *M* sodium iodate, and containing about 5 μc./ml. iodine-131 as iodide. The solution is made 0·025 molar in sulphuric acid to liberate iodine. After immersion for 150 min., the strip is removed, and dried overnight at room temperature, during which time excess unbound iodine-131 is given off.

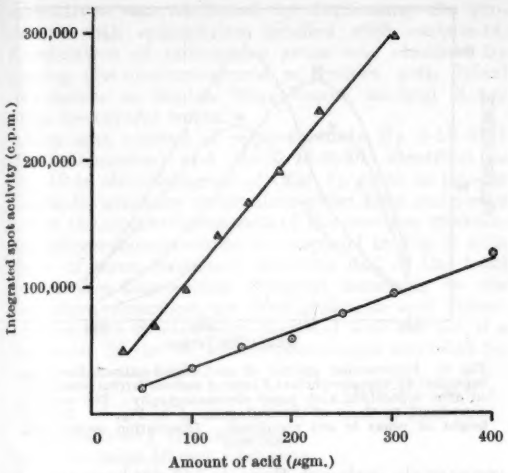

Fig. 1. Relation between integrated spot activity and spot content in chromatograms of oleic (○) and linoleic (△) acids iodinated with iodine-131

Distribution of β-activity is determined by drawing the strip in 2-mm. steps under a 2 mm. × 15 mm. slit in a 'Perspex' screen, 4 mm. thick, located under an end-window Geiger–Müller counter with a window thickness of 4 mgm./cm.[2].

Fig. 1 shows the relation between spot content and integrated total spot activity minus background activity of the paper. A satisfactory, reproducible, linear relation, indicating quantitative or reproducibly proportional iodination, is obtained for oleic and linoleic acids. The radiometric technique has also been used to determine spot length or maximum spot activity, in order to relate these to spot content. Maximal spot activity is defined in terms of β-activity counted through a 2 mm. × 15 mm. slit across the point of maximum activity in the spot, and is clearly related to maximum spot thickness. Linear relationships adequate for estimating spot content are also obtained between spot content and spot length, or between logarithm of spot content and maximum spot activity, for chromatograms of oleic and linoleic acids.

To take account of given experimental conditions a calibration line can be set up by chromatography of known amounts of pure oleic or linoleic acids alongside the fatty-acid mixture. Standards for this purpose can be prepared conveniently by chromatography of 200 mgm. of impure acids under nitrogen on paper strips 300 mm. wide, under the conditions described above, followed by elution from the appropriate bands cut from the paper and titration.

Linear relations between spot length and spot content have not so far been reported in paper chromatography of other substances, and no work seems to have been done on correlation of maximum spot thickness with spot content. In fact, apart from less reliable strip-photometry, radiometric estimation would seem to be the only way of measuring maximum spot thickness at present available.

For routine work this estimation procedure can be speeded up by measuring the background activity of the paper immediately before and after the spot, and taking two or three readings around the area of apparent maximum spot density to locate and measure the maximum spot activity, instead of taking the whole radiochromatogram. For this purpose, to locate the region of maximum spot density approximately, and to define the spot area roughly, a conventional visualization technique (such as use of copper ferrocyanide or rhodamine *B*) can be used in conjunction with the radiometric method.

Further studies are in progress to extend this work.

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Half-wave Potentials of Aromatic Ketones

The unsaturated aromatic ketones undergo irreversible reduction at the dropping mercury electrode to give different products in acid and in alkaline media respectively. In the acid medium the reduction product is a dimeric alcohol, the formation of which may proceed through an intermediate free radical by the following mechanism:

$$2\,R{=}CH{-}CO{-}R \xrightarrow[2H^+]{2e}$$

$$2\,R{=}CH{-}\underset{|}{\overset{R}{C}}{-}OH \longrightarrow R{=}CH{-}\overset{R}{\underset{\cdot}{C}}{-}OH \quad \Big| \quad R{=}CH{-}\underset{\cdot}{\overset{R}{C}}{-}OH$$

The half-wave potential ($E_{1/2}$) for the process is therefore associated with the addition of an electron and a proton to the oxygen atom, and according to the view advocated by us[1,2] the half-wave potential may be related to the O-localization energy. In order to test this hypothesis the O-localization energies, $L(-\beta)$, of benzaldehyde, benzophenone and dibenzalacetone have been calculated by the conventional molecular orbital method (taking the Coulomb integral for oxygen as $\alpha_c + 2\beta$ and for the carbon atom attached to oxygen as $\alpha_c + 0{\cdot}1\ \beta$, where α_c is the Coulomb integral for aromatic carbon and β is the resonance integral for the C—C bond) and are given in Table 1 along with the appropriate values for $E_{1/2}$. It is evident from Table 1 that as the localization energy increases, the half-wave potential also increases. In the case of acetophenone and benzalacetone, the presence of an electron-donating methyl group at the α-position with respect to the C=O group will increase the electron density at the bond, and consequently the energy necessary to add an electron to the oxygen atom in acetophenone will be greater than in benzaldehyde. In fact, in the acid region, the half-wave potential of acetophenone is higher than that of the benzaldehyde. The localization energy for acetophenone could be calculated by the molecular orbital method taking into consideration the hyperconjugation effect of the methyl group, but the calculation is so involved that it was not considered worth the trouble.

Table 1. Localization Energy and Half-wave Potentials for Aromatic Ketones

Compound	pH	$E_{1/2}$ (vs. S.C.E.)*	$L(-\beta)$	$E_M(\alpha - \alpha_c/\beta)$
Benzaldehyde	1·3	0·98	2·6900	0·1900
Benzophenone	1·3	0·94	2·5930	0·1450
Dibenzalacetone	1·3	0·90	2·5178	0·0836

* See ref. 4.

The last column of Table 1 gives the energy (E_M) of the first unoccupied molecular orbital, which according to Maccoll[3] should be related to the half-wave potential of the compound concerned. It is evident from Table 1 that Maccoll's suggestion is equally valid for the reduction of these ketones in the acid region.

In the alkaline region the double bond reduced depends on the nature of the compound. Thus benzophenone is reduced to the corresponding alcohol, whereas benzalacetone gives the corresponding saturated ketone. In one case the C=O bond is reduced, while in the other the C=C bond is reduced. These systems, therefore, cannot be compared by the localization method, although Maccoll's method of adding two electrons to the first empty level will still be valid.

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Fluorescent Derivatives obtained by the Reaction of Ethylene Diamine with Epinephrine and Norepinephrine

In the analytical procedure[1–3] for catechol amines based upon their reaction with ethylene diamine, it is commonly assumed that both epinephrine and norepinephrine form a single fluorescent derivative

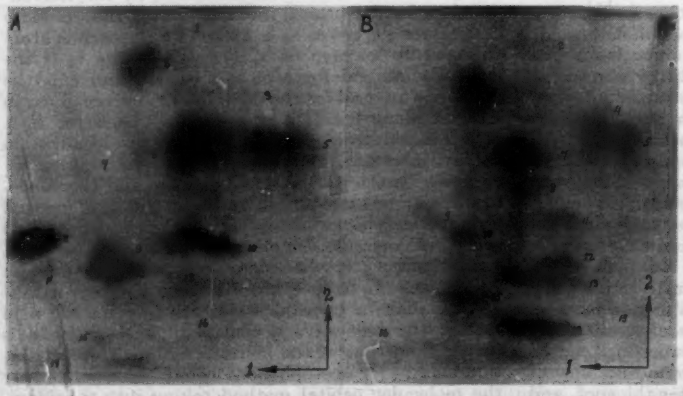

Fig. 1. Two-dimensional chromatograms obtained from epinephrine (*A*) and norepinephrine (*B*), after reaction with ethylene diamine (*iso*butanol extract). Spot Nos. 1, 2, 4, 5, 6, 8, 9, 10, 12 and 16 in chromatogram *A* correspond to radioactive areas obtained from β-^{14}C-DL-epinephrine

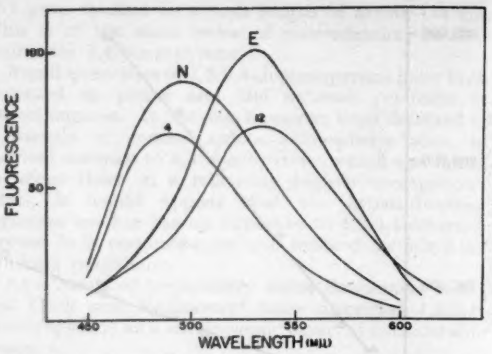

Fig. 2. Fluorescence spectra of *iso*-butanol extract from epinephrine (*E*), norepinephrine (*N*) and of various derivatives obtained after separation with paper chromatography. The numbers correspond to those of chromatogram *A* in Fig. 1. Relative height of peaks is not significant. (Excitation wave-length, 436 mμ)

respectively, although Burn and Field[4] have recently supported the existence, for each amine, of at least two fluorescent products. Gray and Young[5], on the other hand, have failed to demonstrate more than one derivative by means of paper chromatography.

Preliminary trials in this laboratory, with circular paper chromatography (using a highly retentive paper such as Schleicher and Schuell No. 576 and an *iso*-butanol/acetic acid/water developing solvent), gave some indication that the fluorescence obtained by the reaction of ethylene diamine on either catechol amine was due to several constituents rather than to a unique 'condensation' derivative. Further attempts to separate these constituents, either by ascending paper chromatography or by paper strip and curtain electrophoresis, were more or less successful until it was discovered that the large excess of ethylene diamine used for the reaction interfered with proper resolution. When electrophoretic separation on paper strips was then attempted on an *iso*-butanol extract obtained from the reaction with epinephrine, nine bands of fluorescent material were visible under optimum conditions (McIlvaine pH 8·0 buffer diluted 1 : 5 with water, 200 V., 20–25 m.amp. for 4 hr.). The same procedure applied to norepinephrine yielded eight distinct bands.

Better resolution was obtained by means of two-dimensional chromatography on paper, if the excess of ethylene diamine was eliminated either from the reaction mixture or its extracts. Development in a first direction with an aqueous phase (butanol-saturated phosphate buffer at pH 6·0) eliminated most of the unchanged epinephrine and the residual ethylene diamine, which both migrated rapidly, as compared with the other constituents of the mixture. A mixture of *n*-butanol/acetic acid (100 : 15) saturated with water was then used for development in the other direction. Fig. 1 illustrates two typical chromatograms obtained from epinephrine and norepinephrine respectively. The identity of various spots with epinephrine

derivatives was confirmed by duplicating the procedure with epinephrine labelled with carbon-14. Localization of radioactive areas was obtained by placing the chromatograms in contact with Ilford 'No-Screen' or Kodak 'Blue Brand' medical X-ray films for several weeks.

The spot located at approximately R_F 0·58–0·61 (first dimension) and R_F 0·29–0·35, identified as No. 12 in chromatogram *A* (Fig. 1), gives an intense yellow fluorescence under ultra-violet light and forms one of the major constituents of the reaction mixture. Its fluorescence spectrum is compared in Fig. 2 with those of some secondary products and of the total extractable fluorescence obtained according to the procedure described by Weil-Malherbe and Bone[5]. Fluorescence spectra were obtained with the aid of a Beckman 'Model *B*' spectrophotometer modified by us for that purpose[6].

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A Simple and Rapid Method for the Biological Assay of Glucocorticoids

IT has been well established that adrenocortical steroids have a pronounced effect on carbohydrate metabolism, in particular on the level of liver glycogen. Various methods for the assay of adrenocorticoids have been reported[1,2], based upon the ability of these substances to cause a deposition of glycogen in the livers of adrenalectomized rats and mice. However, all these methods appear to be sufficiently complex and tedious to exclude their use when rapid screening procedures are desired. Van der Vies[3] has described two colorimetric methods for the determination of glycogen in body tissues.

In a series of experiments on mice, by modifying the method of Venning, Kazmin and Bell[3], and employing a modification of one of the methods of van der Vies[3], we have produced a simple, rapid, yet highly sensitive method of assaying the glucocorticoid effect of some adrenal steroids.

Male white mice (13–15 gm.) of the Swiss strain produced by the Agricultural Research Council were used in all experiments. The mice are adrenalectomized under ether anæsthesia and maintained on a cube diet (M.R.C. 41*b*) with normal saline for drinking. On the evening of the first post-operative day food is withdrawn and the mice fasted until the following morning. On the morning of the second post-operative day the mice are divided at random into groups of ten and injected intramuscularly with the steroid or test material. Three hours after treatment the animals are weighed as a group, killed by stretching the necks, and their livers extirpated. The whole livers of all the mice in a group are transferred as quickly as possible into 100 ml. of a 5 per cent solution of trichloracetic acid and homogenized or ground with sand in a mortar. The homogenate is filtered under reduced pressure through a Whatman No. 54 paper. A sample of 2 ml. of the filtrate is taken and added to 2 ml. of 10 *N* solution of potassium hydroxide in a boiling-tube. The solution is heated for one hour in a boiling water-bath and then cooled; 1 ml. of glacial acetic acid and 5 ml. distilled water are added. After mixing, 2 ml. of this solution is slowly added to 4 ml. of freshly prepared anthrone reagent (0·2 per cent anthrone in 95 per cent sulphuric acid) in a boiling-tube which is placed in iced water to prevent excessive heating. The solutions are mixed by lateral shaking and placed in a boiling water-bath for exactly 10 min. for colour development, and cooled with tap-water. The extinction is read within 2 hr. in an absorptiometer at 650 mμ against a blank prepared by submitting 2 ml. trichloracetic acid to the same procedure as that described for the liver homogenate. The glucose standards for the calibration curves are prepared by heating three quantities of 2 ml. trichloracetic acid and 2 ml. potassium hydroxide in a water-bath as described above, then adding 1 ml. glacial acetic acid followed by 0·5-ml., 1·0-ml., or 2·0-ml. samples of a 1 mgm./ml. solution of glucose in distilled water. After the addition of 4·5 ml., 4·0 ml. and 3·0 ml. of distilled water, respectively, the procedure is continued in the usual way.

The result is expressed in terms of mgm. liver glycogen equivalent per 100 gm. mouse body-weight.

Venning and her associates[3] demonstrated that specific quantities of glucose administered together with the steroid provoked a striking increase in liver glycogen deposition, although the increase caused by the same dose of glucose administered alone was not significant. In this present study preliminary experiments have corroborated this finding (Fig. 1). These results indicate that doses of either 10 mgm. or 20 mgm. glucose per mouse, incorporated into the injection solution, greatly increase the response to a given dose of cortisone acetate, without themselves

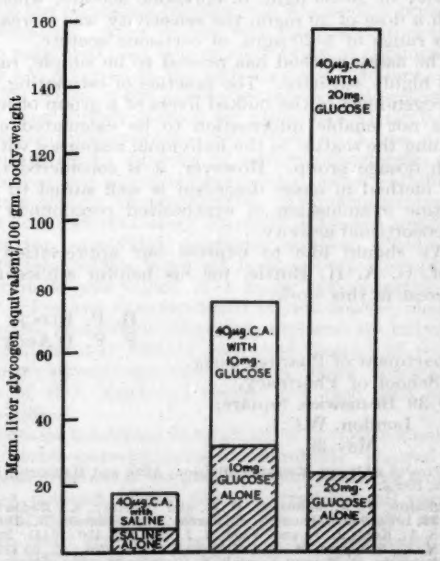

Fig. 1. The effect of glucose, incorporated into the injection solution, on the response produced by a standard dose of cortisone acetate

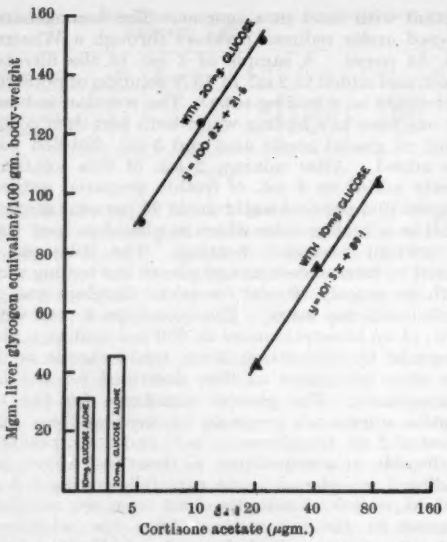

Fig. 2. The effect of glucose, incorporated into the injection solution, in enhancing the sensitivity of the assay method to cortisone acetate

having any pronounced effect on the level of glycogen in the liver. However, further experiments have shown that doses of glucose greater than 20 mgm. per mouse cause deposition of glycogen in the liver. In agreement with the findings of other workers[2] these studies have also shown that there is considerable variation in the liver glycogen response to injected glucose between different strains of mice. Further investigations have shown that the range of sensitivity of the method to adrenal steroids can alter accordingly to the amount of glucose injected with the steroid (Fig. 2). A dose of 10 mgm. glucose injected with the steroid produced a range of sensitivity of 20–80 μgm. of cortisone acetate, whereas with a dose of 20 mgm. the sensitivity was increased to a range of 5–20 μgm. of cortisone acetate.

The assay method has proved to be simple, rapid and highly sensitive. The practice of estimating the glycogen-level of the bulked livers of a group of mice does not enable information to be calculated concerning the scatter in the individual responses within each dosage group. However, it is considered that the method of assay described is well suited to the routine examination of synthesized compounds for glucocorticoid activity.

We should like to express our appreciation to Prof. G. A. H. Buttle, for his helpful advice and interest in this work.

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5-Hydroxytryptamine and Hyperglycæmia

It has been suggested that the hyperglycæmic substance present in the blood of the pancreaticoduodenal vein of animals treated with the growth hormone of the pituitary gland is 5-hydroxytryptamine[1]. This amine may be derived from the enterochromaffin or other cells of the gastrointestinal tract. Yet injections of 5-hydroxytryptamine into normal dogs fail to produce a significant rise in blood sugar, although similar injections into depancreatized animals result in hyperglycæmia. Thus the pancreas may be responsible for the inactivation of 5-hydroxytryptamine.

Recently I have been studying the distribution of 5-hydroxytryptophan decarboxylase, an enzyme forming 5-hydroxytryptamine from 5-hydroxytryptophan, and I was surprised to find that the pancreas possesses a considerable degree of enzyme activity. For example, homogenates of the pancreas of the rat, guinea pig, rabbit, cat and dog all possessed activity, 1 gm. of tissue forming 19–55 μgm. of 5-hydroxytryptamine in 60 min. For comparison, the richest source of the enzyme, namely the kidney, formed 47–188 μgm. of 5-hydroxytryptamine/gm. of tissue. The method of Gaddum and Giarman[2] was followed using 4×10^{-4} *M* substrate, but in place of the choline *p*-tolyl ether I used iproniazid as the inhibitor of monoamine oxidase. When 5-hydroxytryptamine was used as the substrate and iproniazid was omitted from the reaction mixture, it was possible to estimate the monoamine oxidase activity of the homogenates. This showed that 1 gm. of pancreas deaminated 1·2–2·4 μgm. of 5-hydroxytryptamine in 60 min., whereas 1 gm. of kidney inactivated about 8 μgm. of the amine when tested by this method.

The pancreas has not so far been considered as a source of 5-hydroxytryptamine. The present results show that it possesses not only much 5-hydroxytryptophan decarboxylase activity but also monoamine oxidase activity. This latter finding probably explains why the 5-hydroxytryptamine content of the pancreas of the species tested is so low (0·05–0·1 μgm./gm.). It should now be possible to identify the hyperglycæmic substance in the pancreaticoduodenal blood after injections of growth hormone, and to test its action on the blood sugar of animals treated with monoamine oxidase inhibitors such as iproniazid or choline *p*-tolyl ether.

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A Yellow Fluorescent Pigment in Elastin

Mainly due to the pioneer work of Szent-Györgyi[1] it is known that a close relationship may exist between the fluorescence of a certain compound and its activity in energy transfer and thus in metabolism. This suggests that the strong fluorescence of elastin[2], until recently regarded as an inert protein of only structural significance, may be important.

The cause of this fluorescence has not been established. With[3] suggested the presence of firmly

bound pigments originating from porphyrin in elastin, and Partridge and Davis[4] found a yellow pigment in their elastin hydrolysates. Labella[5] was the first to postulate a metabolic function for elastin, suggesting that the presence of an unsaturated lipid is necessary to maintain the particular structure of the elastin molecule. The occurrence of a strong fluorescence was not noticed by the latter authors.

I prepared elastin from ligamentum nuchæ of cattle according to Partridge *et al.*[6]. Partial hydrolysis by activated papain followed by dialysis yielded a clear, bright yellow solution with a yellowish-white fluorescence. Paper chromatography (Whatman 1 or 3 *MM* paper, *n*-butanol/ethanol/0·5 *M* ammonia (70 : 10 : 20) (v/v)) showed a bright fluorescent spot with R_F 0·86, but most of the yellow pigment remained bound to polypeptide residues, as was indicated by subsequent paper chromatography after hydrolysis with hydrochloric acid.

Milligram amounts of the pigment were prepared by hydrolysis with hydrochloric acid. 15 gm. of dry elastin powder were hydrolysed with 600 ml. of 6 *N* hydrochloric acid by refluxing for 24 hr., the hydrochloric acid was removed (by evaporation under reduced pressure in an atmosphere of nitrogen) and the yellow pigments adsorbed on charcoal. The pigments were eluted with hot pyridine, the pyridine was removed completely and the dry residue extracted with dry peroxide-free ether. This solution was washed with 2 per cent sodium bicarbonate and then with a 2 per cent sodium hydroxide solution to extract fluorescent impurities which originate from the action of hydrochloric acid on amino-acids. The pigment was purified by large-scale paper chromatography on Whatman 3 *MM* paper.

A number of properties of the pigment have been determined by chromatography in various solvents, spectrophotometry and chemical spot tests[7].

The pigment is insoluble in water and petroleum ether, but soluble in methanol, ether and chloroform. The absorption spectrum (Fig. 1) shows two distinct absorption maxima, almost independent of the *p*H of the solvent. The R_F value (0·85–0·88) is not altered by substituting acetic acid for the ammonia in the solvent, which also shows that the compound has no distinct acidic or basic properties.

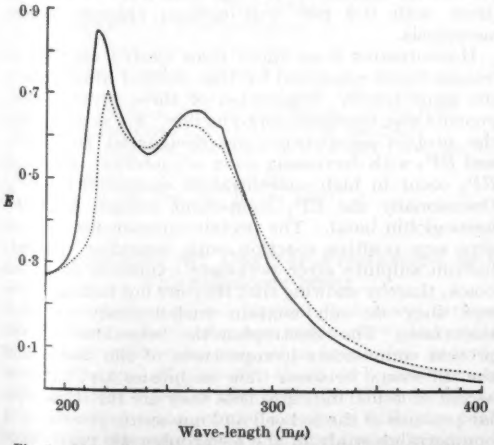

Fig. 1. Absorption spectrum of pigment in 0·01 *N* hydrochloric acid in absolute ethanol (——) and in the same concentration in 0·01 *N* potassium hydroxide in absolute ethanol (– – –)

The presence of the elements carbon, hydrogen and nitrogen was shown, the nitrogen probably being present as a tertiary amine. Oxidation with nitric acid shows the formation of polynitro compounds and the appearance of a carboxylic acid. Spray reagents on paper revealed aromatic hydroxyl groups and a positive Ehrlich diazo reaction. Tests for pyrrole were negative.

Preparation of a larger amount of pigment allows a more exact examination of its properties. These results suggest a structure related to the pyrimidines, purines or pteridines.

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Differential Demonstration of Acetylcholinesterase and Non-specific Cholinesterase in the Adrenal Medulla of the Rat

Using naphthyl acetates as substrates, Coutinho *et al.*[1] demonstrated histochemically that adrenomedullary cells of the rat can be divided into two categories, esterase-positive and esterase-negative. Allen, Eränkö and Hunter[2] confirmed this observation and showed that the regions of those medullary cells which fluoresce in ultra-violet light after fixation in calcium formol and which presumably contain noradrenaline[3] were strongly cholinesterase-positive, while the remaining parenchyma was weakly positive or negative. After studies with some inhibitors they also suggested that two or more types of cholinesterases are involved in the histochemical reactions.

The nature of the adreno-medullary cholinesterases has been further studied by using 62.*C*.47 (1 : 5-*bis*-(4-trimethylammonium-phenyl)pentan-3-one di-iodide), a specific inhibitor of acetylcholinesterase, and tetra-*iso*propylpyrophosphoramide, a specific inhibitor of non-specific cholinesterase[4]. Acetylcholinesterase was demonstrated using Koelle's[5] improved method. Into the prescribed substrate mixture containing acetylthiocholine, however, tetra-*iso*propylpyrophosphoramide was added in a molar concentration of 10^{-6}. For the demonstration of non-specific cholinesterase, acetylthiocholine was replaced by butyrylthiocholine and 62.*C*.47 was used instead of tetra-*iso*propylpyrophosphoramide in a molar concentration of 10^{-5}. Naphthyl acetate was also used as a substrate.

Sections incubated in solutions of acetylthiocholine and tetra-*iso*propylpyrophosphoramide showed a positive reaction in the ganglion cells, the nerve trunks and a network of fine fibres surrounding all parenchymal cell groups. In the fine nerve net, small knobs were strongly positive. After incubation in butyrylthiocholine and 62.*C*.47, ganglion cells and nerve trunks were again strongly stained. On the other hand, the main bulk of the medullary paren-

chyma was essentially negative except for groups of parenchymal cells forming small islets, which were surrounded by a network of strongly positive fibres. Incubation with butyrylthiocholine or with α-naphthyl acetate produced identical results with or without 62.*C*.47. Eserine and tetra-*iso*propylpyrophosphoramide (10^{-6} *M*) inhibited the medullary reaction with these substrates.

Since the reaction worked equally well with fresh-frozen and with calcium formol-fixed sections, it was possible to register photographically, first the distribution of the calcium formol-induced fluorescence, and then that of the cholinesterases. It was thus proved that the regions of the fluorescent cell groups showed a high, the non-fluorescent parenchyma a low, activity of non-specific cholinesterase.

Non-specific cholinesterase can be demonstrated in a specific way with butyrylthiocholine even without 62.*C*.47. This was done, the section was photographed, incubated with acetylthiocholine and 10^{-6} *M* tetra-*iso*propylpyrophosphoramide to detect acetylcholinesterase, and photographed again. Comparison of the pairs of photographs thus obtained confirms very clearly the different distributions of acetylcholinesterase and the non-specific esterase in a single section. Similar differentiation could not be obtained using di-*iso*propylfluorophosphate, which has commonly been used to inhibit non-specific cholinesterase[5].

Denervation of the adrenals was followed by a total disappearance of acetylcholinesterase from the medulla, except for the cytoplasm of some ganglion cells, but did not affect the distribution of non-specific cholinesterase in the fluorescent parenchyma. Prolonged treatment with nicotine, on the other hand, resulted in an increase in the intensity of the non-specific cholinesterase reaction, and the reaction was more widely spread in the medulla than normally.

These results justify the conclusion that there are in the adrenal medulla of the rat two types of cholinesterases, which behave differently towards different substrates and different inhibitors. Of these the type which is sensitive to 62.*C*.47 and which disappears after denervation is apparently a specific acetylcholinesterase coupled to the mechanism of nervous transmission. The other enzyme, which is sensitive to tetra-*iso*propylpyrophosphoramide, affected by treatment with nicotine and selectively localized in the regions of the parenchymal cells containing noradrenaline, may be connected with the metabolic processes of these parenchymal cells.

Further details of the methods and results will be published elsewhere.

This work has been supported by a research grant from the National Institute of Arthritis and Metabolic Diseases, U.S. Public Health Service (*A*–1725). Samples of 62.*C*.47 were obtained through the courtesy of Dr. F. C. Copp, The Wellcome Research Laboratories, tetra - *iso*propylpyrophosphoramide through the courtesy of Messrs. L. Light and Co., Ltd.

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Agar Electrophoretic Patterns of Red Blood Cell Proteins

It has been previously reported from this laboratory that both animal (rat)[1,2] and human[3] red blood cell hæmolysates show the presence of minor protein components other than hæmoglobin after electrophoresis in agar gel medium. Because of their possible interaction with hæmoglobin molecules in the red cell and their variation in hæmatological disorders and other pathological conditions, more detailed study of these proteins appeared of interest.

Stern *et al.*[4], in a preliminary study, demonstrated the presence of proteins other than hæmoglobin by moving-boundary electrophoresis. The hæmolysates examined (man, dog and chicken) showed the presence of a small amount of an opalescent, colourless fraction (protein *a*) with anodic mobility (at *p*H 8·6) twice as high as that of oxyhæmoglobin. This protein component was assumed to be derived from the membrane or stroma of the cells. In addition to this component, human and dog hæmolysates were found to contain another colourless component (protein *b*) with a mobility smaller than that of hæmoglobin, while chicken red cell hæmolysate was found to contain a component (protein *c*) with a mobility intermediate between that of hæmoglobin and protein *a*. Hoch[5] reported the occurrence of two components faster than the oxyhæmoglobin in fresh red-cell extracts.

The minor protein patterns observed by the agar electrophoresis technique showed marked difference from the moving boundary patterns obtained by Stern *et al.* and Hoch. At least three minor protein components, in addition to hæmoglobin, are present in human red blood cell hæmolysates, with mobilities lower than that of hæmoglobin, and no fast-moving component (protein *a*) was observed.

The method of separation of these proteins by agar electrophoresis followed the procedure presented previously, except that higher concentration of the hæmolysate was used to reveal the minor protein components, some of which will not be visible at the low concentrations used in previous experiments reported earlier. After electrophoresis, the proteins were stained with amido black 10*B*[6].

Fig. 1 is a typical pattern showing the minor protein components and the hæmoglobin in human red-cell hæmolysate. The red cells were washed six times with 0·9 per cent sodium chloride before hæmolysis.

Hæmolysates from more than twelve samples of human blood examined by this method always gave the same result. Separation of three protein components was, therefore, reproducible. For convenience the protein components are designated RP_1, RP_2 and RP_3 with decreasing order of mobility. RP_1 and RP_2 occur in high concentration compared to RP_3. Occasionally the RP_1 component merged with the hæmoglobin band. The protein components did not give any positive reaction with benzidine reagent, fuchsin sulphite after periodate oxidation or sudan black, thereby showing that they are not hæmoglobins and they do not contain carbohydrate or lipid materials. The electrophoretic behaviour of the protein components (compactness of the bands and the difference between their mobilities and those of serum proteins) indicates that they are the intracellular proteins of the red cell and not serum proteins. A comparative study of the electrophoretic patterns of human serum proteins and hæmolysates obtained on the same plate showed that the mobility of RP_2

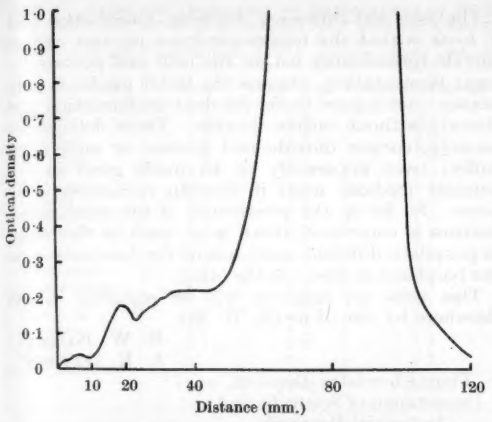

Fig. 1. Agar electrophoretic pattern of human red blood cell proteins. (8·6 *p*H; 200 V., 8 m.amp., 10 hr. run, 80 μl. of hæmolysate applied on the gel)

approached that of γ-globulin, while RP_1 and RP_2 possessed mobilities between those of γ- and β-globulins of serum. The relative amounts of RP_1, RP_2 and RP_3 as determined from the areas of the peaks obtained by densitometric measurement are approximately 40, 46 and 14 respectively (excluding hæmoglobin). Animal red blood cells (rat and sheep) also contain these proteins to a varying degree. It will be of interest to investigate the variation of these proteins in red blood cells under pathological conditions and their significance in relation to hæmoglobins, and sickling phenomena and allied hæmatological disorders.

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Pre-requisites for Dextran Production by *Streptococcus bovis*

In a recent paper[1] we showed that many strains of *Streptococcus bovis* of rumen origin gave good yields of an unbranched dextran when incubated anaerobically for one day at 38° C. in a liquid sucrose medium. An essential condition for these yields of dextran was either incubation in a 100 per cent carbon dioxide atmosphere or the incorporation of solid calcium carbonate or 0·01 *M* bicarbonate in the medium. The latter was well buffered with 0·05 *M* phosphate and also contained 0·5 per cent yeast extract and 1·1 per cent casitone, or an equivalent peptone as sources of organic nitrogen, and growth factors. In the absence of carbon dioxide, cell yields were almost as good as in its presence and, though a normal lactic acid fermentation took place, little or no dextran was produced. No detailed study of the effect of buffer strength and composition on dextran yields nor any attempt to simplify the medium was made at the time.

We now find that:

(*a*) Adequate buffering of the medium is a prerequisite for high dextran yields. Reducing the phosphate to a level (0·01 *M*) which was still adequate for good growth and fermentation, almost completely stopped production of dextran even though carbon dioxide was supplied. As found by Whiteside-Carlson and Carlson[2] with *Leuconostoc*, phosphate could, with advantage, be replaced by acetate, since the latter can be used at a much higher concentration than phosphate (up to 0·25 *M*) without affecting growth. The effect of acetate concentration (in the presence of bicarbonate ion) on the conversion of sucrose to dextran and free fructose by *S. bovis* is shown in Table 1. High yields of dextran and of free fructose can be obtained after incubation for only 24 hr. at 38° C. without any external neutralization of the culture. Acetate can be replaced by propionate or butyrate or even by salts of organic acids of much lower pK_a values, such as lactic and formic acids. In these later cases the dextran yield is lower than with acetate of equivalent concentration.

(*b*) A carbohydrate and protein-free basal medium suitable for dextran production was devised by replacing the casitone and yeast extract by acid-hydrolysed casein and a mixture of B vitamins and growth substances similar to those used for *Leuconostoc* by Whiteside-Carlson and Carlson[4]. According to Ford, Perry and Briggs[5], *S. bovis* requires no B vitamins for anaerobic growth; nevertheless we have clear evidence that pantothenic acid is absolutely necessary for the anaerobic production of dextran. Unlike *Leuconostoc*, however, *S. bovis* still requires carbon dioxide and a buffer in conjunction with this simplified medium for production of dextran to occur.

(*c*) Carbon dioxide gas in solution and not the bicarbonate ion is the first essential requirement for production of dextran. This follows from the following observations relating to sucrose cultures of *S. bovis* containing the correct phosphate *and bicarbonate*

Table 1. Effect of Acetate Buffer on the Conversion of Sucrose to Dextran, Fructose and Leucrose by *S. bovis* (Strain I)

Acetate (*M*)	Dextran (percentage conversion of available glucose)	Free fructose (percentage of available fructose)	Leucrose (percentage of available sucrose)	Residual sucrose (by paper chromatography)
(1) Medium 0·5 per cent 'Bacto' yeast extract, 1·4 per cent 'Bacto'-tryptose, 8·5 per cent (w/v) sucrose and 0·004 *M* potassium carbonate (sterilized separately); 24-hr. incubation at 38° C.				
0·0	0·0	—	—	+++++
0·036	6·2	—	—	+++++
0·055	14·5	—	—	++++
0·073	26·8	—	—	+++
0·091	36·0	—	+	++
0·110	73·8	—	++	+
0·128	87·0	60·0	6·0	0
0·147	89·0	71·7	7·3	0
0·184	87·0	87·0	12·2	0
(2) Medium as for (1) above except that sucrose 12 per cent (w/v); incubated 48 hr. at 38° C.				
0·184	85·2	67·5	10·1	0
0·256	79·6	63·8	8·1	0

concentrations for production of dextran, through which a slow, oxygen-free, stream of hydrogen was bubbled at 38° C. for 24 hr. (1) The organism would not grow at all if the hydrogen stream was free from carbon dioxide. (2) There was fair growth without formation of dextran if the hydrogen was first bubbled through 0·5 per cent sodium bicarbonate solution at room temperature to supply a trace of carbon dioxide, since bicarbonate solutions tend to revert to carbonate with loss of carbon dioxide even at room temperature. (3) There was good growth and good formation of dextran with conditions exactly similar to (2), except that the hydrogen was bubbled through saturated (10 per cent) sodium bicarbonate solution. We conclude that the concentration of carbon dioxide in solution needed for production of dextran is much higher than that essential for growth. The bicarbonate may function merely as a source of carbon dioxide at low *p*H values brought about by production of lactic acid rather than as the ion itself. In contrast, *Leuconostoc mesenteroides* still grew and produced dextran even when a stream of hydrogen free from both oxygen and carbon dioxide was bubbled through the sucrose medium at 28° C.

Not all rumen strains of *S. bovis* behave similarly, but even those strains that do not appear to have a definite need for carbon dioxide for slight production of dextran nevertheless require good buffering of the medium for production of dextran to occur. Temperature is a factor of importance in certain cases. We have one strain which appears to need carbon dioxide for formation of dextran at 38° but not at 28° C. Other strains behave similarly at both temperatures, except that growth is necessarily slower at 28° C. The organism will also grow at 47° C. in the presence of bicarbonate and high phosphate buffering, but no dextran is produced.

In contrast to *Leuconostoc*, the dextran formed at 28° C. is also unbranched. Addition of 0·008 *M* magnesium ion to the acetate-buffered medium, although resulting in only a trace of precipitate on autoclaving, did not produce branching in the *S. bovis* dextran at either 28° or 38° C. (cf. ref. 6).

As with *Leuconostoc*, good yields of dextran can be obtained only in sucrose media. A point of considerable importance, however, is that the specific soluble enzyme concerned (which appears to act as a dextransucrase; cf. ref. 7) is produced quite prolifically, by *S. bovis* at least, in a glucose liquid medium (particularly if it contains a mere trace of sucrose) as well as in a sucrose liquid medium. The enzyme was produced even when the culture used for inoculation had been carried through five successive tubes of glucose liquid medium and hence contained no trace of sucrose or apparently of dextran. The dextransucrase of *S. bovis* therefore appears to be constitutive rather than adaptive. Karström[8] long ago asserted that the *Leuconostoc* (*Betacoccus arabinosaceous*) enzyme system for dealing with sucrose was constitutive and not adaptive. However, he grew the organism at 37° C. and carried out his experiments with the washed cells in non-nutrient media at 45° C. It is unlikely, therefore, that he was studying *Leuconostoc* dextransucrase, which is mostly secreted extracellularly and is unstable at these temperatures[7]. Actually he had previously stated[9] that the sucrase of *Leuconostoc* is a glucosucrase; no mention was made of dextran as a product. The question of the adaptive or constitutive nature of *Leuconostoc* dextransucrase appears to be worth re-investigating.

The essential difference between *Leuconostoc* and *S. bovis* is that the former produces its own carbon dioxide (presumably within the cell) and acetate by sugar fermentation, whereas the latter produces only lactate—not a good buffer for dextran formation (see above)—without carbon dioxide. These deficiencies (namely, carbon dioxide and acetate or equivalent buffer) have apparently to be made good in the nutrient medium itself if dextran formation is to occur. So far as the production of the unbranched dextran is concerned, there is no need at this stage to postulate different mechanisms for *Leuconostoc* on one hand and *S. bovis* on the other.

This work on enzymes will be reported in full elsewhere by one of us (R. W. B.).

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Content of Citrulline and Other Amino-Acids in a Protein of Hair Follicles

Citrulline has been shown to occur in the fibrous protein of the inner root sheaths of hair follicles[1]. This appears to be the first recorded occurrence of citrulline in an animal protein, although Smith and Young[2] described its presence in the protein of the red alga, *Chondrus crispus*.

In view of the unexpected occurrence of citrulline, it was of interest to investigate the quantitative composition of the protein of the inner root sheath and to compare it with the composition of the hair with which it is associated in the follicle.

Samples of inner root sheaths, hair roots and of the hairs themselves were prepared from vibrissa follicles of the rat[1]. They were dried in vacuum at 60° C. over phosphorus pentoxide and hydrolysed in sealed tubes for 10 hr. at 105° C. with constant-boiling hydrochloric acid, and subjected to quantitative amino-acid analysis by the ion-exchange chromatographic technique of Moore and Stein[3,4] as modified in this laboratory[5].

Because of the difficulty of obtaining sufficient inner root sheath and hair root material only single analyses were possible and the total nitrogen contents were not estimated. The analytical results could be expressed only as per cent dry weight (Table 1).

Control runs of authentic samples of *l*-citrulline and *l*-ornithine confirmed the identity of the peaks of these two amino-acids with those obtained in the analytical runs.

The analytical figure for citrulline confirms the earlier evidence that this amino-acid is a major component of the protein of the inner root sheath. However, the value reported is probably low because some of the citrulline is destroyed during hydrolysis

Table 1. Amino-acid Composition of Hydrolysates of Hairs, Hair Roots and Inner Root Sheaths from Vibrissa Follicles of the Rat

Per cent by weight of sample dried at 60° C. over phosphorus pentoxide

Amino-acid	Hair	Hair roots	Inner root sheath
Alanine	3·5	3·2	3·1
Amide	1·2	1·2	0·4
Arginine	7·8	7·7	5·1
Aspartic	5·8	6·1	7·1
Cystine	13·7	7·4	1·0
Glutamic	11·6	11·4	>18·8*
Glycine	5·1	4·2	2·9
Histidine	1·3	1·4	1·0
iso-Leucine	1·9	2·0	1·6
Leucine	5·5	6·0	7·1
Lysine	3·1	3·2	2·8†
Methionine	—	—	0·1
Phenylalanine	2·7	3·2	2·7
Serine	8·6	6·7	3·9
Threonine	4·6	3·9	2·4
Tyrosine	4·4	4·1	2·1
Valine	3·1	2·9	1·8
Citrulline	—	—	6·1
	83·9‡	74·6‡	70·0‡

* This must be regarded as a minimum figure since the optical density exceeded the limit for accurate reading by the equipment.
† Including ornithine produced from citrulline breakdown.
‡ The recoveries are all low. The analyses do not include tryptophan and proline, and have not been corrected for material not containing protein, such as pigment, nucleic acids, lipids and carbohydrates which are present to an unknown extent.

with the production of ornithine[1], a fact overlooked by Smith and Young, who used longer hydrolysis times in their analysis of *C. crispus*. It was unfortunate that in the present analysis ornithine was not resolved from lysine, and hence the citrulline and lysine contents could not be corrected. The low amide and small lysine plus ornithine figures suggest that this correction is not large.

Comparison of the analytical results shows that the fibrous protein of the sheath contains very little cystine, although methionine is present in greater amount than in hair. Of interest are the low arginine content and the extraordinarily high glutamic acid concentration in comparison with the values for hair, aspartic and glutamic acids together constituting more than 26 per cent of the protein. The low amide content implies that few carboxyl side-chains are amidated. Despite the lack of disulphide bonds compared with hair keratin, the protein of the sheath is not dispersed at alkaline *p*H values or by concentrated urea solutions[1]. If secondary forces are held responsible for this stability, these might be found in the increased possibilities for the formation of strong salt links and hydrogen bonds due to the high concentration of polar side-chains and to citrulline, which itself is a substituted urea.

Although the significance of citrulline in follicle metabolism is unexplained, it has been suggested[1] that the protein of the sheath provides ammonia to the growing hair for amidation of the side-chain carboxyl groups. Thus with the appropriate enzyme system present in the follicle, some arginine side-chains could be de-imidated to citrulline and ammonia. An enzyme system of this type has been described in extracts from crayfish muscle[6]. The amino-acid composition of the protein, in particular the low arginine and amide content, despite a high concentration of dicarboxylic amino-acids, and the high content of citrulline are in accord with this suggestion.

Comparison of the composition of hair roots with that of hair (Table 1) shows that the amide contents are similar, and so also are the amino-acid contents, excepting cystine, which is considerably lower in hair roots. This is in accord with the general view that the final cystine content of hair is established at a late stage in keratinization.

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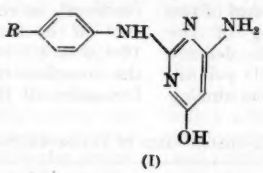
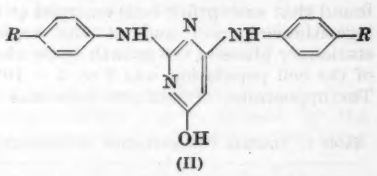
Arylaminopyrimidines as Growth-Inhibitors of *Streptococcus faecalis* and *Lactobacillus arabinosus*

It has been found by Hitchings *et al.*[1] that 2 : 4-diamino-6-alkylpyrimidines which have bulky substituents (for example, phenyl) at C_5 are strong folic acid antagonists, some of which have marked antimalarial[2] and antileukæmic properties[3]. Furthermore, Curd, Rose and their co-workers had shown previously that many 6-alkylpyrimidines having substituted amino-groups at C_2 and C_4 were active as antimalarials[4].

In continuation of our studies of pyrimidines of potential chemotherapeutic interest, we have prepared several 2-arylamino-4-amino- and 2 : 4-diarylamino - 6 - hydroxypyrimidines (types I and II respectively) (methods of synthesis will be described elsewhere).



(I)



(II)

As shown in Table 1, these substances, particularly the di-arylamino compounds (II), caused marked inhibition of growth of *Streptococcus faecalis* and *Lactobacillus arabinosus*. However, these compounds differ from the parent member of the series, namely,

Table 1. Inhibition of *S. faecalis* and *L. arabinosus* by Arylamino-pyrimidines

Compound	*S. faecalis**‡ Conc. (μgm./ml.) for 50 per cent growth inhibition	*L. arabinosus*†‡ Conc. (μgm./ml.) for 50 per cent growth inhibition
2:4-Diamino-6-hydroxy-pyrimidine	90	220
(I; *R* = H)	40	46
(I; *R* = CH_3)	30	39
(I; *R* = Cl)	12·5	17
(II; *R* = H)	8·0	11
(II; *R* = CH_3)	4·5	6·2
(II; *R* = Cl)	0·8	1·0

* Medium contains pteroylglutamic acid (1 mμgm./ml.) but no purine or pyrimidine metabolites. All other essential nutrients are included (ref. 5).
† Medium contains 20 μgm./ml. each of adenine, guanine, xanthine and uracil but no pteroylglutamic acid (ref. 5).
‡ Growth measured turbidimetrically after 20 hr. at 37° C.

2 : 4-diamino-6-hydroxypyrimidine, and from most other 2 : 4-diaminopyrimidines in that the growth inhibition of *S. faecalis* which they cause is not reversed by the presence of folic acid.

The effects of 2 : 4-diarylamino-6-hydroxypyrimidines on various forms of parasitic growth are now being examined.

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Effect of Monovalent Cations on Type Specificity Transformation in Pneumococci

For investigating the mechanism of bacterial transformation we have chosen as the experimental model the transformation of the *R* form of *Diplococcus pneumoniae* type II into the mucous form of *D. pneumoniae* type III, by means of crude extracts of deoxyribonucleic acid, isolated from the mucous form of *D. pneumoniae* type III. Systematic study was hampered by considerable variability in the results and by the low incidence of transformation in the control tubes.

Alexander *et al.*[1], working with *H. influenzae*, found that susceptible cells emerged at the end of the logarithmic period and at the beginning of the stationary phase of the growth-cycle when the density of the cell population was 2 to 4 × 10^8 cells per ml. The appearance of sensitive cells was lowest during the early logarithmic phase. Another important factor influencing the number of cells capable of transformation is the concentration of deoxyribonucleic acid (up to 10^{-1} μgm. per ml.). In practice, when all the above factors are present, only about 1 per cent of the *Haemophilus* recipient population undergoes transformation. In the case of pneumococci[2], 0·2–5 per cent of the exposed population was transformed.

Serum factors, which are necessary in the transformation of types of pneumococci, have been studied in detail[2–6].

Fox[7], without giving any particular details, describes the effect of calcium ions on the increase in the number of transformed cells during transformation of resistance in pneumococci.

In our experiments we were concerned mainly with the problem of how to eliminate variability of the transformation results with the *R* strain in question, with the question of the causes of this variability and with the possibility of increasing the number of *R* cells capable of transformation.

The experiments were carried out with an *R* strain of *D. pneumoniae* type II, obtained from the mucous form of *D. pneumoniae* type II in our laboratory by Griffith's method[8]. The crude extracts of deoxyribonucleic acid were obtained from young 4–6 hr. plate cultures of a strain of *D. pneumoniae* type III, by McCarty and Avery's method[9], using five- or six-fold deproteinization, but without specially removing the polysaccharides and ribonucleic acid. Ultra-violet absorption curves showed maxima in the region of 2580 A. and minima in the region of 2300 A.

Using as transformation method the experimental procedure of Avery *et al.*[3] it was found that the presence of salts with monovalent cations (dipotassium hydrogen phosphate, disodium hydrogen phosphate, potassium chloride, sodium chloride and to a lesser degree ammonium chloride and ammonium sulphate) in the classic neopeptone anti-*R* serum (10 per cent) medium[3], in concentrations of about 5 × 10^{-2} *M* to 10^{-1} *M* in the case of phosphates, and of about 10^{-1} *M* to 3 × 10^{-1} *M* in the case of chlorides, helped in the complete elimination of chance results in transformation of the *R* strain into the mucous form of

Table 1. Optimal Concentration of Potassium and Sodium Salts in Transformation of Type Specificity in the Strain PMSII

Molarity (*M*)	Neopeptone broth											
	K_2HPO_4						$Na_2HPO_4.12H_2O$					
	inoculum 2 hr.			inoculum 4½ hr.			inoculum 2 hr.			inoculum 4½ hr.		
	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48
5×10^{-3}	000	000	000	000	000	000	000	000	000	000	000	000
10^{-2}	000	000	000	000	000	000	000	000	000	000	000	00+
2×10^{-2}	000	000	000	000	000	000	00+	00+	00+	+++	+++	+++
5×10^{-2}	000	000	+00	0++	0++	+++	0++	0++	+++	+++	+++	+++
$6{\cdot}72 \times 10^{-2}$	000	00+	+++	+++	+++	+++	0+0	0+0	0++	+++	+++	+++
10^{-1}	+++	+++	+++	+++	+++	+++	+00	+00	+++	+++	+++	+++
Molarity (*M*)	KCl						NaCl					
	inoculum 2 hr.			inoculum 4½ hr.			inoculum 2 hr.			inoculum 4½ hr.		
	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48
$1{\cdot}5 \times 10^{-2}$	000	000	000	000	000	000	000	000	000	000	000	000
3×10^{-2}	000	000	000	000	000	000	000	000	000	000	000	000
9×10^{-2}	000	000	000	000	000	000	000	000	000	000	000	000
$1{\cdot}5 \times 10^{-1}$	+00	+00	+00	+++	+++	+++	000	000	000	+00	+00	+00
2×10^{-1}	+00	+00	+0+	+++	+++	+++	000	0++	0++	+++	+++	+++
3×10^{-1}	000	000	+++	+++	+++	+++	+00	+00	+++	+++	+++	+++

Results in three control series, in which the results were read off after 16, 20 and 48 hr. growth in the liquid medium by subculturing at the indicated time on to glucose blood agar plates twice from each test-tube. The macroscopic identification was confirmed by agglutination with the homologous immune serum. 0, No transformation found. +, Transformation positive.

D. pneumoniae type III. Neither the height of the agglutinating titre nor the sodium or potassium content of the anti-*R* sera used had any effect in the results given in Table 1. Transformation was not promoted by calcium chloride. In the presence of lithium and magnesium salts (probably activating deoxyribonuclease) and of cobalt, the medium was sterile.

It was verified experimentally that neither the phosphate buffer nor the quality of the anions was important, and the active part in successful transformation was played by the monovalent cations. Table 1, in which the control, that is, the plain neopeptone broth, shows negative results, gives the results of experiments with a 2- and a 4½-hour inoculum of the *R* strain, containing 220 and 1,330 cells respectively per ml. of the medium. Transformation of the *R* strain to the mucous form of pneumococcus type III commences, under the given conditions, at a concentration of 3×10^{-2} *M* for disodium hydrogen phosphate and 5×10^{-2} *M* for dipotassium hydrogen phosphate. In the presence of potassium chloride and sodium chloride, transformation commences at a concentration of about $1{\cdot}5 \times 10^{-1}$ *M*.

If transformation is observed throughout growth of the culture in the transformation system, the cells of an *R* culture can be successfully transformed in the presence of the above salts, from the commencement of the growth-cycle to the stationary phase. A young *R* culture requires a somewhat higher concentration of salts than an older culture to give uniform transformation results (Table 1).

It is possible that the part played by the above ions is related to the permeability of the cell membrane to the large deoxyribonucleic molecule, although they may act on the deoxyribonucleic acid molecule itself. The cell appears to become more permeable with age, when the outer membrane loses its vitality in the transition from Gram-positivity to Gram-lability, at the end of the logarithmic phase of the growth-cycle and at the commencement of the stationary phase. Gram-labile cells from the primary culture are also found in a newly inoculated medium at the onset of growth. This would provide an explanation of the finding[1] that transformation can be detected better in cells which have been growing from zero to two hours than later, during the active phase of the growth-cycle. At the end of the logarithmic phase the cells form large Gram-labile groupings. These are probably the same groups of susceptible cells described by Hotchkiss[3] which successively develop and disappear as the culture grows, remain capable of transformation for about 15 min. and then lose this property.

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Applications of Erythrocyte Stromata Powder

Blood displaying positive serological reaction for syphilis and erythrocytes of blood stored for more than 21 days are usually discarded in blood banks. The erythrocytes of such blood samples were utilized for the preparation of erythrocyte powder. They were washed with saline and hæmolysed with distilled water. The stromata were then washed three times with distilled water cooled to 6° C. Thereafter, the stromata sediment was lyophilized and pulverized in a mortar. The drying could also be carried out at 37° C., the stromata being spread in a thin layer; but the lyophilized preparation was more active. About 1,500 mgm. of fine, pink powder was obtained from 200 ml. of packed red cells. The powder could be stored at 4° C. for at least two months without any appreciable loss of activity. Before use, the requisite amount of the powder was weighed out and washed twice with saline, care being taken to prepare a suspension free from lumps. In this way the powder was cleared of almost all remaining hæmoglobin.

Absorption of antibodies. The erythrocyte powder was successfully used for the absorption of anti-A and anti-B antibodies from test sera of human origin (anti-Rh, anti-Duffy, anti-Kell, etc.). 10–20 mgm. of powder were used for the absorption of 1 ml. of serum. First, a small amount of serum was added to the washed powder sediment, and a diffuse suspension was prepared by vigorous stirring with a glass rod; then the remaining volume of serum was added. The tubes were kept for 2–3 hr. at room temperature, being frequently shaken. Thereafter, the tubes were centrifuged and the serum withdrawn. The absorption performed in this way was almost always complete, and it had to be repeated only in exceptional cases. The absorption of anti-A and/or anti-B antibodies from anti-D serum could be performed not only with Rh-negative but also with Rh-positive erythrocyte powder heated after washing (as a moist sediment) for 10 min. at 56° C.

Absorption of anti-human hetero-agglutinins from rabbit anti-globulin serum was performed by the same technique; the powder of A erythrocytes being used preferably.

For the absorption of anti-D antibodies, 50 mgm. of Rh_0-positive powder per 1 ml. of serum was used. The absorption required 2 hr. at 37° C. Repeated absorptions were frequently required for complete exhaustion of antibodies.

Preparation of 'pure' antibodies. The elution of blood-group antibodies from the red cells has been practised since 1925 [1], but the methods used did not yield 'pure' antibodies in a high titre or in a solution free of ballast proteins. Some progress was made by the application of stromata[2,3].

50–200 mgm. of powder was sensitized with 10–100 ml. of serum. Sensitization with anti-A and anti-B antibodies occurred over a period of 2 hr. at room temperature, and, with anti-D, 2 hr. at 37° C. The sensitized powder was washed three times with saline and suspended in saline or AB serum. About one drop of saline or serum was added per 4 mgm. of powder. The tubes were shaken for 5–7 min. in a water-bath at 56° C., and centrifuged in a 500-ml. flask filled with water warmed to 56° C. The eluate was then withdrawn. The saline eluates were water-clear and contained only about 10 mgm. per cent

proteins. The titre of the anti-A and anti-B antibody preparations was up to 1,000.

The anti-D antibody eluate obtained in AB serum had all the properties of an incomplete anti-D serum, titres up to 1 : 2,000 being obtained in colloidal medium. In this way, an anti-D serum group O could be 'changed' into an anti-D serum group AB.

The anti-D antibody eluate obtained in saline did not agglutinate Rh_o-positive cells, but it sensitized Rh_o-positive red cells up to a dilution of 1 : 100 for the action of Coombs serum. Washing the sensitized cells could be omitted without any influence on the reaction. The indirect Coombs test could also be performed by adding saline suspension of Rh_o-positive cells to the mixture of Coombs serum with saline eluate of anti-D. This phenomenon can be explained by the lack of normal globulins in the saline eluate. This observation may possibly be of practical importance for the simplification of the indirect Coombs technique.

Complement fixation test. All test components were added in 0·25-ml. volumes; inactivated serum at 1 : 5 dilution, erythrocyte powder in suspension containing 1–5 mgm./ml. Fixation and incubation were performed at 37° C. Out of forty-three normal sera tested, only five gave positive reactions due to anti-A and/or anti-B antibodies. Three sera from women belonging to group O, who gave birth to infants with hæmolytic anæmia due to ABO incompatibility, were also tested. Two of these sera, with high titre of anti-A and anti-B respectively, gave a strongly positive reaction with A and B erythrocyte powder respectively. The third serum, with a high titre of anti-A, gave only a doubtful reaction.

Immunization of rabbits. A suspension containing 20 mgm. of washed powder injected daily intravenously into rabbits produced no morbid symptoms. Very large amounts of powder could be given subcutaneously or intramuscularly without doing any harm. The application of this method for MN immunization is under investigation.

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Production of High-Titre Diphtheria Toxin in Baffled Shake Flasks

Successful production of high-titre diphtheria toxin has already been described[1], involving aluminium tanks containing 10 or 50 l. of medium. The inoculated medium was stirred at 1,400 r.p.m. so that a vortex was produced, and under these conditions high-titre toxin was obtained in 48 hr. The inocula for the tanks were produced in shake flasks[2] which gave relatively poor results after 48 hr. shaking, and which could not in any way be compared with tanks. Thus no simple method existed which would give high-titre toxin in 48 hr. and which could be used on a scale small enough to allow the easy handling of large numbers of cultures in the laboratory. It was felt that some improvement might be expected if the aeration of the shake flasks was improved, and this led to the use of baffled shake flasks[3]. In the present work 1-l. Erlenmeyer flasks were used, into which single glass baffles (approximate dimensions, 50 mm. high, 25 mm. wide and 1 mm. thick) were fused. On a rotary shaker (140 r.p.m., $\frac{1}{2}$ in. radius) these gave an oxygen uptake at the start of the shaking period of 120 ml. oxygen/100 ml./hr. as measured by the sulphite oxidation technique[4]. This compared with 30–40 ml. oxygen/100 ml./hr. for an unbaffled flask under the same conditions, and the difference was due entirely to the surface of the medium being continuously broken up on the baffle. When no baffle was present the surface of the medium as it swirled around in the flask remained unbroken and no air bubbles were incorporated into the liquid.

For studies on toxin production, the flasks, plugged with cotton wool, and containing 100 ml. medium (either a tryptic digest medium based on that described by Linggood and Fenton[2] or a papain digest medium based on that of Ramon *et al.*[5]) were inoculated with 1 ml. of a 48-hr. culture of a Park-Williams No. 8 strain of *Corynebacterium diphtheriae* previously grown in an unbaffled shake flask. The flasks were placed on the shaker, which was in an incubator room at 35–36° C., and the toxin production was estimated 48 hr. later. A comparison of results from baffled and unbaffled flasks and tank cultures is given in Table 1.

Table 1. *Lf*/ml. Values of Filtrates of *C. diphtheriae* grown for 48 hr. in Submerged Culture

Medium		Unbaffled flasks (average of 3 × 100 ml. cultures)	Baffled flasks (average of 3 × 100 ml. cultures)	Aluminium tanks (average of 4 × 60 l. tanks and 3 × 10 l. tanks)
Papain digest	*BP* 489	100	260	195
	BP 490	30	130	250
	BP 491	—	260	265
	BP 494	80	160	165
	BP 508	180	190	215
	BP 530	—	250	285
	BP 535	95	165	305
Tryptic digest	*P* 1,457	—	235	210
	P 1,458	—	240	195

A big improvement is seen in the toxin titres produced on most batches of media when baffled flasks are compared with unbaffled ones, and it is clear that the new method is often comparable with tank culture. With some batches of media (for example, *BP* 508), however, no advantage of baffled over unbaffled flasks was found, and further, when baffled flasks are compared with tanks, some media give much better results in the tanks (*BP* 535) and some much worse (*BP* 489). Thus the conditions under which toxin is produced in the two systems do not seem to be identical and conclusions drawn from the results produced in one method must be applied with caution to the other. A possible explanation of the differences lies in the different methods used for aerating the cultures. The oxygen uptake of the tank system is relatively low, being about 40 ml. oxygen/100 ml./hr., but since air is flowing continuously over the vortex this value should remain fairly constant. With baffled flasks the initial uptake of oxygen is high, but as the oxygen in the flask is used up it is replaced by air. Thus the oxygen available and the rate of uptake of oxygen diminish, and so the growing organism may be subjected to quite different sets of conditions in the two methods. This work suggests some relation between respiration and production of toxin in the organism, the exact nature of which is

Table 2. Effect of Detergents on Toxin Titres produced in Baffled Shake Flasks

Medium	Detergent added	*Lf*/ml. (average of 3 × 100 ml. cultures)
BP 505	None	105
	0·1 per cent sodium stearate	265
BP 508	None	190
	0·05 per cent sodium stearate	220
	0·01 per cent 'Calsolene'	250
BP 512	None	195
	0·02 per cent 'Tween 80'	250

obscure, and it may be that optimum conditions vary for each batch of medium.

To illustrate the difference between flasks and tanks, the effect of detergents on production of toxin in baffled shake flasks is shown in Table 2. As can be seen, the results were sometimes quite dramatic, increases of 50–150 *Lf*/ml. being achieved. In view of this, detergents were added to tank cultures, but in that case they were without effect. The reason for this lack of conformity is not clear. It is known that stirring at 1,400 r.p.m. produces very much more foam in the medium than is ever produced in baffled flasks, and it seems possible that the detergent acts by forming a layer of foam in the baffled flask, thus slightly reducing the uptake of oxygen. This would imply that it is possible to over-aerate cultures of *C. diphtheriae* when high-titre toxin is being aimed at, and further work along this line is in progress.

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Dependence of Bone Marrow Cells on the Liver for Purine Supply

It is well known that higher organisms can utilize the carbon atom of formate molecules for the synthesis of purines, as indeed can liver tissue *in vitro*. However, in rabbit and human bone marrows and in Ehrlich ascites cells of the mouse, formate-^{14}C was found to be utilized very inefficiently for *de novo* synthesis of purines *in vitro*, but very efficiently for labelling thymine in deoxyribonucleic acid[1–3]. As liver extracts restore the ability of these cells to synthesize purines *in vitro*[4], it was suggested that, *in vivo*, the capacity of bone marrow cells for synthesis of purines may be so limited that they depend on the liver for the supply of purines. This inference was tested experimentally by measuring the amount of formate-^{14}C incorporated into the deoxyribonucleic acid bases of bone marrow cells in control and hepatectomized rabbits.

Rabbits weighing 1·5–2·0 kgm. were used. They were bled on each of the two days before the experiment to ensure an actively regenerating marrow. Rabbit 1 was not anæsthetized, to serve as a control for the effects of anæsthesia (chloralose, 80 mgm./kgm.) in the others. In rabbits 4 and 5, as much of the liver as possible was removed (about 95 per cent). This procedure introduced two other factors which may have complicated the interpretation of the results: trauma and cessation of blood flow through the intestine. To test whether these conditions were influencing the results, further experiments were necessary. Both kidneys were removed from rabbit 3 as a control for trauma, and the intestinal tract was removed in rabbit 6. As this latter operation cut off a large proportion of the blood supply to the liver, it was repeated in rabbit 7, but with restoration of the portal blood flow by anastomosis of the inferior vena cava to the stump of the portal vein.

Five to ten minutes after the operations, sodium formate-^{14}C (500 μc./kgm., specific activity, 4 mc./m.mole) was given intravenously. The rabbits were killed by exsanguination 90 min. later and the femoral and tibial bone marrow was removed. The deoxyribonucleic acid bases in the bone marrow were isolated, and the specific radioactivity measured as described before[3]. The results are shown in Table 1.

There was little difference between the ratios of specific activity of thymine/adenine in the non-anæsthetized control, anæsthetized and nephrectomized rabbits. The mean ratio was 1·05, indicating a similar degree of incorporation of formate-^{14}C into both the purines and the thymine of the deoxyribonucleic acid in bone marrow cells *in vivo*. More labelled adenine was found in the bone marrow from the unanæsthetized rabbit, giving a ratio for the specific activity of thymine/adenine of 0·5, but because of the expenses involved, further experiments to test the significance of this difference were omitted.

In the hepatectomized rabbits, the incorporation of formate-^{14}C into the adenine of bone marrow cells was substantially depressed, thus raising the thymine/adenine ratio to 27. A similar thymine/adenine ratio was found in the rabbit where the intestine was removed, with arrest of the portal circulation. In the rabbit in which portal blood flow was restored after removal of the intestines, the thymine/adenine ratio was 3·17, indicating that formate-^{14}C was efficiently utilized in the formation of bone marrow adenine. This was in spite of the fact that intraportal injection of ink stained only about 50 per cent of the liver at the end of the experiment. In

Table 1. Specific Activities of the Thymine and Adenine of Deoxyribonucleic Acid from Rabbit Bone Marrow 1½ hr. after an Intravenous Administration of 500 μc. Formate-^{14}C per kgm. Body-weight (Counts per min./μ*M* Base)

	Rabbit 1, control, no anæsthetic	Rabbit 2, control, anæsthetic	Rabbit 3, control, nephrectomy	Rabbit 4, hepatectomy	Rabbit 5, hepatectomy	Rabbit 6, portal occl.	Rabbit 7, caval-portal anastomosis
Thymine	450	600	570	138	40	347	589
Adenine	900	380	543	5	1·5	17	186
Ratio (*T*/*A*)	0·5	1·6	1·05	28	27	20	3·17

one animal (rabbit 5) the blood pressure fell to 35 mm. mercury soon after hepatectomy and, as might be expected, the synthesis of both purines and thymine was depressed. Nevertheless, the thymine adenine ratio still indicated the importance of the liver for the synthesis of purines.

These experiments show that the *de novo* synthesis of purines in bone marrow cells is greatly reduced by hepatectomy. It is unaffected by nephrectomy or by removal of the gastro-intestinal tract, as long as the portal blood flow is maintained. Three interpretations of these results are suggested: (1) In animals, the liver provides an enzyme with which the bone marrow cells can synthesize purines. (2) The liver provides an advanced precursor which the bone marrow cells can transform into purines. (3) The liver supplies preformed purines which are taken up by bone marrow cells.

If the liver provides an enzyme, it must have a very short life, for in our experiments even 5–10 min. after hepatectomy the bone marrow cells cannot utilize formate-^{14}C efficiently for synthesis of purines.

If the liver supplies an advanced precursor to the bone marrow, then bone marrow cells *in vitro* should be able to utilize 5-amino-4-imidazole carboxamide or its riboside (one of the last steps in the purine pathway). It has recently been shown[5] that these substances are utilized very inefficiently for synthesis of purines compared with the uptake of adenine-^{14}C into purines or of formate-^{14}C into thymine.

This leaves the third possibility, which is further supported by the observations that although bone marrow cells *in vitro* have a limited capacity for purine synthesis, they can utilize preformed adenine very efficiently[6]. We can conclude, therefore, that in the mammalian organism, the liver is the main source of purines for the bone marrow cells, and possibly for the cells of most peripheral tissues.

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Elimination of Macrophage Cells of the Reticulo-Endothelial System by Way of the Bronchial Tree

It has been demonstrated by Nicol[1] that vitally stained macrophages appear cyclically in the uterine endometrium and that they are greater in number in the follicular phase of the œstrous cycle and their number and activity may be increased experimentally by œstrogens. The dye-bearing macrophages were not observed within the uterine blood vessels although some were seen to lie close to them. The appearances throughout the uterus and vagina provided convincing evidence that the dye-bearing macrophages are similar to many of the rounded cells, with dense nuclei and no dye, frequently seen within the capillaries and passing through the blood vessel walls in the circular muscle zone. From this it was inferred that the blood is the chief source of these macrophages, although some of them may be derived from the connective tissue cells of the endometrium.

It was later shown by Nicol and his colleagues[2] that œstrogens have a strong stimulating influence on the reticulo-endothelial system generally and that this results in the appearance of large numbers of macrophages in the spleen and liver and the mobilization of these cells into the circulation. In the spleen of control animals a relatively small number of vitally stained cells was normally present in the sinuses and in the reticulum, and in the liver only a few dye-bearing Kupffer cells were seen. After œstrogenic treatment, however, the number of dye-bearing cells became considerably increased in both liver and spleen and many of these were liberated and could be seen free in the splenic sinuses, splenic vein and intralobular veins of the liver, but they were not seen in the splenic artery. The present research was designed to study the fate of the hepatic and splenic macrophages which become free and enter the blood-stream.

For this investigation 36 male white mice (T.O. Swiss strain) of 20–30 gm. body-weight were used. Each animal received one subcutaneous injection of 0·5 mgm. of œstradiol benzoate once daily for 6 days and then one injection of 4 mgm. of carbon of particle size 250 A. into the dorsal vein of the penis on the eighth day. The animals were divided into six groups and blood samples were taken under anæsthesia at either 2 min., 2 hr., 1, 2, 3 or 4 days after the carbon injection from each of the following sites—splenic vein, portal vein; hepatic vein, inferior vena cava, right heart; left heart, retro-orbital plexus, saphenous vein. The animals were then killed and smears were taken from the lungs and bronchi, and the trachea was tied at two points and an isotonic solution of saline used to wash out the contents of the lumen for microscopical examination. In addition, specimens of the liver, spleen and lungs were fixed in Heidenhain's 'Susa' fluid and sections were cut 10μ thick and stained with dilute eosin or carbol fuchsin.

The results were as follows: carbon-containing macrophages were found in the splenic sinuses, splenic vein, portal vein, liver sinusoids, intralobular veins, hepatic vein, inferior vena cava and right heart blood; but were not seen in the left heart blood, retro-orbital plexus and saphenous vein.

Two minutes after the injection a considerable amount of carbon was seen in the macrophages of the spleen and liver and a heavy concentration in the lumen of the capillaries of the lungs. Two hours later the macrophages of the spleen and liver contained a great amount of carbon, but in marked contrast no carbon was seen in the lungs. Forty-eight hours later a small number of carbon-containing macrophages was seen in the alveolar walls of the lungs, and 4 days after the injection a moderate number could be seen free in the alveoli. Carbon-containing macrophages were also found in the smears from the lungs and bronchi and in the washings from the trachea; they were well differentiated in the bronchi and lower trachea but in the upper respiratory passages they were disintegrating.

It has previously been reported[2] that when a known amount of carbon is injected intravenously about 90 per cent of the carbon is removed from the blood by the Kupffer cells of the liver, 3 per cent by the phagocytes of the spleen and the remainder by those of the bone marrow, lymph nodes and connective tissue. In the present investigation our use of œstrogens to stimulate the reticulo-endothelial macrophages and of carbon as a marker has enabled us to identify, not only the liver and spleen as the important sites of active phagocytosis, but also the distribution of the hepatic and splenic phagocytes liberated into the circulation, and their elimination by the lungs.

Florey[4] states that the lung is particularly rich in phagocytes, whatever their origin, for there is a constant demand for their activity to keep the alveoli clear of dust particles and other material. He states that in some species cells have been described within the alveolar walls which are thought to be capable of becoming detached phagocytes, but probably many of the lung phagocytes develop from blood monocytes. He also points out that it has been suggested that they may be replenished by showers of cells produced by division of the Kupffer cells of the liver which enter the circulation and are caught up in the lung capillaries. The cells then pass into the alveolar spaces and are seen there as large round cells containing particles like carbon from the air or hæmosiderin from extravasated red blood cells, and many of them probably pass up the bronchial tree.

Our results show that the blood channels within the lungs are poor in phagocytes, but that under certain conditions there is a liberation of phagocytic cells from the liver and spleen which enter the circulation and pass to the lung capillaries; and that when they contain ingested material like carbon they do not travel through the lungs into the left heart and peripheral circulation but pass into the bronchial tree and up the trachea to be expectorated or swallowed. Our evidence therefore gives support to the concept that the lung macrophages may be augmented or derived from the liver and spleen. It may be that the heart failure cells and dust cells of the lungs are also of hepatic and splenic origin.

The results appear to be of clinical significance since they indicate one method by which disease may be disseminated.

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Lack of 'Slow-Alpha' Proteins in some Guernsey Cattle

Out of about 2,500 cattle sera examined during the past two years by starch gel electrophoresis[1], two individuals were found which lacked a slow alpha (Sα) protein zone (Fig. 1). Both animals were Guernsey cattle, one a five-year-old cow and the other her twelve-month-old heifer calf. This suggests that the condition is inherited. The herd from which the cow originated was examined for the absence of Sα-proteins. The part of the pedigree which is relevant is shown in Fig. 2.

Fig. 1. Part of the anodic side of a starch-gel electropherogram carrying three cattle sera, the central one lacking Sα-proteins. β, β_1-globulins; T1 and T2, thread proteins

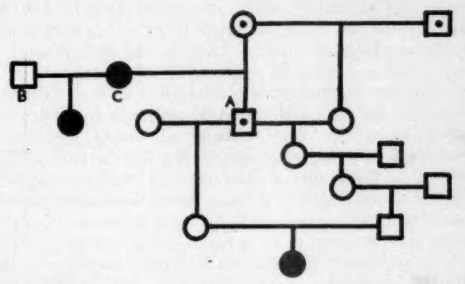

Fig. 2. Pedigree of part of a Guernsey herd in which some animals lack Sα-proteins. Solid circles denote affected females. Symbols with dots indicate animals which were not available

It seems likely that the Sα-protein (or proteins) is controlled by a pair of allelomorphic genes, $S\alpha^A$ and $S\alpha^O$. The genotypes $S\alpha^A/S\alpha^A$ and $S\alpha^A/S\alpha^O$ would then give phenotypes with Sα-proteins, while the genotype $S\alpha^O/S\alpha^O$ would lack them.

The relatively high frequency of $S\alpha^O$ in this herd seems to be due to a bull (unfortunately dead) which must have been homozygous for this allele. This particular bull (*A* in Fig. 2) was the result of a cross between two animals which had the same dam.

Insufficient information is available to assess the frequency of $S\alpha^O$. However, the bull *B* (Fig. 2), presumably $S\alpha^A/S\alpha^O$, is at present standing at a cattle breeding centre and is used extensively. No further examples of individuals lacking Sα-proteins were found among his progeny from fourteen matings picked at random from other herds.

The animals lacking Sα-proteins were in good health and did not show any signs of abnormalities. In fact, the five-year-old cow (*C*, Fig. 2) gave the best individual milk yield of cows in milk-recording Guernsey herds in Staffordshire for two successive years. Each of the bull *A*'s five daughters in the herd has shown a milk yield above average in each lactation.

The nature of the Sα-proteins in the cow is not known, but an analogous protein in humans has been shown recently by Poulik and Smithies[3] to be a glycoprotein of high molecular weight. A protein zone of this type has been found in all the mammalian sera so far examined, with the exception of the Guernsey cattle shown in Fig. 2 and two horse sera.

I wish to thank Mr. K. O'Sullivan, deputy regional veterinary officer of the Milk Marketing Board, for his generous co-operation.

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Emergence of a Summer Species of Dragonfly

Two types of British dragonfly have been recognized, namely, spring and summer species. Spring species (for example, *Anax imperator* Leach, *Pyrrhosoma nymphula* (Sulzer)) have been defined as those having a diapause in the final larval instar and, in consequence, a closely synchronized emergence. In summer species (for example, *Aeshna cyanea* (Müller), *Lestes sponsa* (Hansemann)) diapause is by definition absent from the final instar, although sometimes developed in another stage in the life-history[1]. The lack of a final instar diapause in summer species made it seem likely that emergence in this ecological group would be less closely synchronized than in spring species, and that in some cases it might inherit from the larval population a time – frequency distribution approaching normality[2]. Although emergence of *L. sponsa* has been found to be temporally dispersed[3], when compared with that of *P. nymphula*[2], its exact temporal distribution and duration have hitherto remained unknown. Recently, however, the emergence pattern of another summer species, *A. cyanea*, has been determined directly by means of exuvia counts made in Nature, and the results provide a striking confirmation of expectation.

In Fig. 1 the emergence curve of *A. cyanea* is compared with that of *A. imperator*, a spring species in the same family and of similar size. The two curves differ significantly in the degree of their synchronization, a point well demonstrated by comparing the times during which 50 per cent of the annual population emerged: this stage was reached by the third day of emergence in *A. imperator*, but not until the twenty-fifth day in *A. cyanea*. Total duration of emergence in the two species was, however, approximately the same, being 44 days and 49–55 days, respectively.

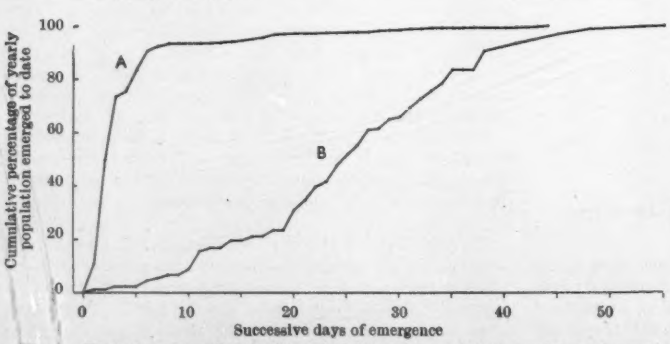

Fig. 1. Time-frequency distributions of adult emergences in (*A*) a spring species and (*B*) a summer species. *A*: *Anax imperator* in Berkshire during 1953; emergence began on May 25 and finished on July 7. *B*: *Aeshna cyanea* in Hampshire during 1957; emergence began on June 29 and finished between August 16 and 22

Such large differences in the temporal distribution of emergence will have important effects on other stages in the life-history. For example, early population pressure at the breeding site, and the resulting dispersal during the first few days of maturity, will probably be far more pronounced in spring species than in summer species. Also, the ecological demand for reproductive longevity will supposedly be greater in summer species, in which adult populations are heterogeneous with respect to the age of their members. In this connexion it is interesting to note that, in a Dorsetshire pond, Moore[4] found the flying season of *A. cyanea* to be very much longer than that of *A. imperator*.

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Feeding Habits of Emperor Penguins

The feeding habits of emperor penguins (*Aptenodytes forsteri* Gray) have been described by previous authors[1–5]. Most agree that the birds have access to the sea through tide cracks. During the winter of 1957 in Antarctica, I was able to observe this phase of the birds' activities and can now amplify previous comments.

The breeding cycle of the emperor penguin is peculiar in that it occurs in the depth of the antarctic winter. After the laying of the single egg (in May in most rookeries) the female bird leaves the rookery for approximately nine weeks while the male bird incubates it. No trace of the females is seen until hatching commences, when they return in large numbers to the rookery to commence feeding the chicks while the males go to sea to end their long fast. The chicks grow rapidly, and the constantly increasing demand for food means that both parent birds travel to and fro from the feeding places, gorging themselves with fish and krill, then regurgitating food for the chicks.

Taylor rookery (67° 28′ S., 60° 53′ E.), fifty miles west of the Australian National Antarctic Research Expedition's base Mawson, is unique in that it is situated in an old glacial valley adjacent to the sea. All other known rookeries, with the exception of the one at Dion Islets, are located on sea ice. It is flanked by a glacier on its western side and is surrounded by a ring of high hills which afford much protection from wind. During the chick-feeding period here, the majority of birds do not travel more than two or three miles to feeding holes. Between the glacier and some nearby islands are a number of tide cracks, parts of which are kept open by glacier movement, Weddell seals, and feeding emperor penguins which congregate in large numbers near these holes. An interesting fact is that the birds do not feed for very long at these holes. Presumably

this is because fish and krill in the area rapidly diminish against the onslaught of many hungry birds. When this occurs the hole is deserted and the birds move elsewhere.

At this time of the year, a few birds are seen to travel seawards past the thickly populated feeding grounds, and are probably going farther afield for food, although I did not follow these birds.

A new emperor penguin rookery was discovered by an Australian party in August 1957 at approximately 67° 25′ S., 64° 00′ E. It is situated on sea ice held in by grounded bergs. At this time its population was approximately 12,000 adults and 8,500 chicks. A large feeding hole was found at the same time six miles south of the rookery at the base of a tilted iceberg. There were nearly 100 birds present, with many large groups of birds going to and from it.

The complete absence of female birds near the antarctic coast during the incubating season means that they must travel far out to sea, possibly to the pack ice fifty or one hundred miles away. However, their mode of travel is almost certainly not walking. In May several of these females were seen to enter the water through seal holes close to the Fold Island rookery (67° 20′ S., 59° 23′ E.), 90 miles west of Mawson, and appear again at more distant holes. Swimming from hole to hole beneath the sea ice would provide them with a much more rapid method of travel than walking, and it would be possible for them to cover large distances in a relatively short period.

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May 17.

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An Outbreak of Subcutaneous Tumours in Rhesus Monkeys

SUBCUTANEOUS tumours have developed in a colony of Indian rhesus monkeys (*Macaca mulatta*) at the laboratories of the West African Council for Medical Research, Lagos, Nigeria. We are using the word 'tumour' in a wide sense without any implication that the growths described are true neoplasms.

The colony in which the outbreak occurred consisted of approximately thirty-five animals housed in a row of four adjacent pens, with indoor and outdoor compartments; two further pens, situated at one end of these four pens and adjacent to them, contained various West African monkeys. A row of six smaller pens was situated 100 yards from the main rhesus pens and at the time of the commencement of the outbreak housed other assorted West African monkeys. Contact between monkeys in adjacent pens frequently occurred by the extension of a limb of one animal through to the next cage. The rhesus monkeys in the affected colony varied in age from new-born to approximately six years. The majority of adults had, at one time or another, been used for virus studies and had been returned to the pens after recovery from infection.

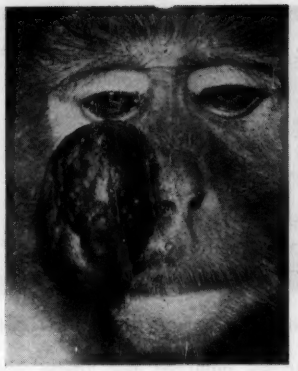

Fig. 1. Adult female rhesus monkey (case 2) with growth of three and a half weeks duration

No tumour had been observed in any species of monkey prior to June 15, 1957. On this date an adult male rhesus monkey, housed in one of the two centre pens, was seen to have a tumour, approximately 1 cm. in diameter, on the right eyebrow. During the following week the growth rapidly increased in size and an adult female situated in the other of the two centre pens was found to possess a similar growth on the nose (Fig. 1). During the ensuing weeks the condition spread rapidly, and by the end of the year had affected approximately twenty animals. In the early stages an unsuccessful attempt was made to limit the outbreak by separating tumour-bearing animals into individual cages; later, affected rhesus monkeys were placed in three of the six smaller pens normally housing West African monkeys. During October 1957, one young dog-faced baboon (*Papio papio*) situated in one of the three remaining small pens was found to have developed a tumour on the nose.

During the course of the outbreak, animals of all ages became affected by the condition. Tumours occurred most frequently on the lower portion of the limbs or dorsal aspect of the feet and hands, otherwise on the face or ears, never on the trunk. Affected animals did not appear sick or emaciated and seemed to be little inconvenienced unless suppuration of the tumours took place. During the early stages of the outbreak the condition appeared to be relatively mild, only single tumours occurring on affected monkeys; but as the outbreak assumed greater proportions an apparent increase in severity occurred, multiple tumours arising along the course of the lymphatic vessels draining a tumour-bearing area. Unless destroyed, affected animals recovered spontaneously, the growth sloughing away and the area healing by granulation. No attempt was made to treat the condition other than by local excision of tumours and the combating of secondary infection.

The tumours arose in the subcutaneous tissue, and in the earlier stages were seen as small, slightly reddened papules. Once initiated, growth ensued with great rapidity, tumours fungating through the skin and attaining a diameter of 2–4 cm. in as many weeks. At biopsy and post-mortem examinations the tumours were found to be adherent to the underlying structures and to be non-encapsulated. On section the tumours were light pink in colour and without visible structure. The regional lymph nodes

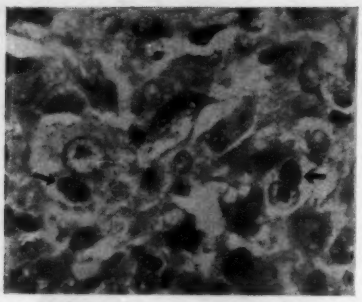

Fig. 2. Section of tumour showing cytoplasmic bodies (arrows)

were frequently enlarged but freely mobile. No metastases were found in any of the viscera in animals brought to autopsy.

Histological examinations showed that the bulk of the tumour was composed of pleomorphic cell types, the predominant cell (Fig. 2) being large with abundant cytoplasm. The cytoplasm of the majority of these cells contained one or more acidophilic, rounded or irregular bodies varying in size between 1 and 5μ and resembling virus-induced inclusions. In some cases there was a moderate degree of fibrous tissue reaction and an infiltration with inflammatory cells. No bacteria, fungi or protozoa were seen in tissue sections. In deeper layers of the growths tumour cells were frequently seen infiltrating between underlying muscle fibres. Enlarged regional lymph nodes were often seen to contain cells resembling those characteristic of the tumours.

The disease has been transmitted by subcutaneous inoculation of lightly centrifuged emulsions of tumour material to healthy rhesus monkeys and to two West African guenon monkeys (*Cercopithecus aethiops tantalus*). Attempts to transmit the condition to West African mangabeys (*Cercocebus torquatus torquatus*), to Patas monkeys (*Erythrocebus patas patas*) and to laboratory white mice have been unsuccessful.

Tumour material has been forwarded to Dr. C. H. Andrewes, National Institute for Medical Research, Mill Hill, London, for further investigation by his colleagues and himself; they have obtained evidence that the causative agent is a virus, as will be reported later.

Our thanks are due to Dr. F. N. Macnamara, director of the Virus Research Unit, for permission to publish this communication.

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Epidermal Structures in a Rhinoceros (*Ceratotherium simum*)

Most accounts of rhinoceros skin detail its more obvious characteristics, namely, its rough, wrinkled and mammillated exterior, its well-keratinized epidermis and its thick, weighty and inelastic dermis. Concerning the structure of such skin and the possible presence of epidermal derivatives (other than horns) information is curiously wanting in authoritative zoological treatises[1]. It is frequently stated that body hairs, save those constituting the ear- and tail-fringes, are lacking in the Rhinocerotidae, though Beddard[2] recognized an unobtrusive and rather sparse hairy covering as a general familial character.

Neuville[3] observed hairs around the base of the horn in the three Asiatic species (*Rhinoceros unicornis*, *R. sondaicus*, *R.* (*Didermocerus*) *sumatrensis*), and Lydekker[4] considered *Didermocerus* a form specially prone to hairiness, the so-called species '*Rhinoceros lasiotis*' being based on nothing more than a particularly hirsute specimen. Bigalke *et al.*[5] described, in an infant *Ceratotherium simum*, a very sparse hairy covering, becoming less obvious with advancing age, and we have noted a discrete hair tuft upon the nuchal eminence of an immature animal of this species. Reliable records as to the hairiness of young specimens of *Rhinoceros unicornis*, *R. sondaicus* and *Diceros bicornis* appear to be lacking.

It is probable that in some rhinoceros species at least, as in the elephant, the neonatus manifests an extremely sparse hairy coat which disappears gradually either as the result of friction or the accumulation of subcutaneous fat.

It is not surprising, therefore, that recent microscopical examination of the cervical and abdominal skin of an immature specimen of *Ceratotherium* should reveal the presence of hair follicles (provided with sebaceous glands) containing greater or lesser portions of well-formed hair shafts. Most unexpected, however, was the finding of large apocrine sweat glands, characterized by an abundance of relatively large, ectodermally developed myoepithelial cells, an anatomical arrangement clearly subserving the rapid and copious discharge of sweat.

The skin examined was freshly procured and well fixed in the field; after paraffin blocking it was sectioned with difficulty, the best sections being 15μ–20μ in thickness. These stained well with hæmatoxylin and eosin, and with Mallory's triple stain.

Study of these skin sections reveals (*a*) a heavily keratinized and pigmented epidermis, 1 mm. thick, showing the customary component layers save for a stratum lucidum, (*b*) an exceedingly thick (18–20 mm.) and dense dermis, composed exclusively of pure collagen fibres disposed in every direction to the skin surface, and (*c*) hair follicles, hairs, sebaceous glands and apocrine sweat glands. The entire skin appears remarkably vascular. The ordinary small type of sweat gland is not observable.

The obtrusively large apocrine sweat glands are not particularly numerous, although estimation of their incidence is precluded by the thickness of the sections. Each gland surrounds, in open basket fashion, the base of a hair follicle and appears to be supplied by an independent arteriole: its spiral duct is fairly capacious in its intra-dermal course, but narrows perceptibly in its intra-epidermal course. A striking feature of the glands and ducts is the association therewith of large and numerous ectodermally developed myoepithelial cells: these lie between the secretory cells and the basement membrane of the glands and are disposed helicoidally around the ducts.

These distinctive apocrine sweat glands seem to have escaped previous notice in *Ceratotherium* and it is not known whether they occur in other rhinoceros species. Histologically the skin of *Ceratotherium* is demonstrated to be of typically mammalian constitution and to lack none of the customary epidermal derivatives. It is specialized in respect of the degree of keratinization of its epidermis, the thickness and

purely collagenous nature of its dermis and the size and structure of its peculiar sweat glands.

A detailed account of the skin histology will be published elsewhere.

We are deeply indebted to Dr. E. H. Williams, of Arua, for the collection and preservation, under difficulty, of the material studied.

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Lolium temulentum L., a Long-day Plant requiring only One Inductive Photocycle

Cooper[1] has recorded that *Lolium temulentum* is a long-day summer annual which shows no response to vernalization by low temperatures, and has no sharply defined critical photoperiod. My results, however, indicate that at least one strain of the species is a strict long-day plant, and that it can be induced to form normal inflorescences by exposure to only one long day.

The plants used were derived from the selfed progeny of a single Canadian plant, and were grown under controlled environmental conditions in the Earhart Laboratory, Pasadena. After seedling establishment in 8-hr. photoperiods, groups of plants were distributed to a series of photoperiod regimes at 17° C. under mixed incandescent and fluorescent illumination at an intensity of 1,200 ft.-candles throughout the photoperiod. The times of inflorescence initiation were determined by periodic dissection, and it may be seen from Table 1 that initiation was considerably delayed in photoperiods less than 12 hr. in length, and did not occur in 9-hr. photoperiods within 180 days. Initiation of inflorescences in this strain of *L. temulentum* thus appears to have an absolute requirement for long days.

Table 1. Number of Days required for the Initiation of Inflorescences in Plants of *L. temulentum* grown at 17° C. under Incandescent and Fluorescent Illumination at an Intensity of 1,200 ft.-candles

Photoperiod length (hr.)	8	9	11	12	13	15	24
Days to double ridge appearance	—	>180	95	28	18	14	8

Groups of plants, which had been grown for five weeks in 8-hr. photoperiods, were exposed to a varying number of long days at 23–17° C. before being returned to short-day conditions. The rates of development of their inflorescences in short days at 23–17° C. subsequent to induction were determined by the dissection of five plants in each treatment group each week. All plants received 8 hr. of natural illumination daily, and during treatment were given photoperiod extensions at intensities of 12, 40 or 400 ft.-candles at plant height. Both continuous light and 16-hr. photoperiods were used for induction. Of the plants not exposed to long days, none showed any sign of inflorescence initiation within 140 days. Their apices did, however, increase in length throughout the period of the experiment, due to the accumulation of unexpanded leaf primordia. On the other hand, all the plants exposed to long-day conditions in all series, even those exposed to only one 16-hr. photoperiod of low intensity, either eared or displayed unambiguous inflorescence initiation on dissection. This strain of *L. temulentum* thus has a sensitivity to photoperiodic induction comparable to that of *Xanthium pensylvanicum* among short-day plants. It should be noted, however, that maximum photoperiodic sensitivity is not attained until the plants have been grown for about five weeks in short-day conditions at 23°–17° C. After only 14 days in that regime the plants need four days of continuous light for induction, while seedlings 21 and 26 days old require, respectively, three and two days of continuous light.

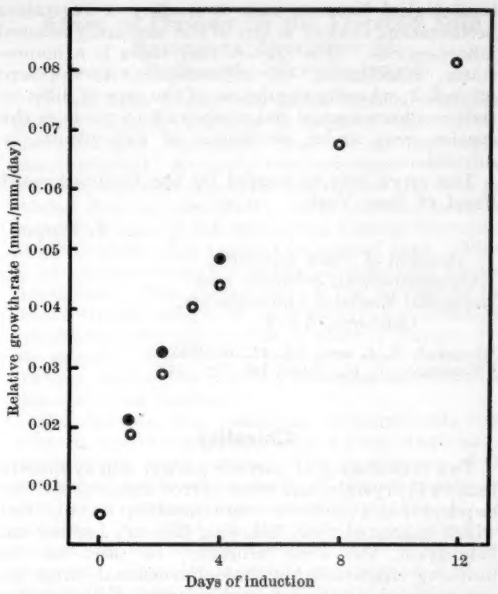

Fig. 1. The effect of the number of days of continuous light induction on the relative growth-rate of inflorescences of *L. temulentum* in 8-hr. photoperiods at 23–17° C.: ○ with day-length extensions of 400 ft.-candles intensity, ○; with day-length extensions of 40 ft.-candles intensity, ●

In the controlled environmental conditions available for these experiments, the increase in apex length among induced plants was exponential with time, and it may be seen from Fig. 1 that the relative growth-rate of *L. temulentum* inflorescences, in 8-hr. photoperiods at 23–17° C. after initiation, was greatly affected by the number of long days to which the plants had been exposed. The rates were, in fact, approximately proportional to the logarithm of the number of inductive photocycles given. They were, moreover, highly reproducible, and provide a sensitive index for kinetic analyses of the inductive process.

Variation in the number of long days to which the plants were exposed had no effect on the number of spikelets formed in each inflorescence, nor were

teratological features, such as sterility or vegetative proliferation, evident in any of the minimally induced inflorescences. This implies that there is a homeostatic canalization of inflorescence development (cf. ref. 2) whereby regulation of the rate of differentiation allows normal morphogenesis to occur in this species even under conditions of sub-optimal induction.

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Chirality

The importance of particle parity, non-symmetric tensors in crystals, and other mirror-image properties, requires that a previous communication[1] be amplified, which suggested that, following Kelvin[2], Larmor and Eddington, the term 'chirality' be used for the property characterizing three-dimensional forms not superposable on their mirror images. Kelvin wrote[3] "I call any geometrical figure, or any group of points, *chiral*, and say it has *chirality*, if its image in a plane mirror, ideally realized, cannot be brought to coincide with itself". Unfortunately the definition in the Oxford English Dictionary—"*chiral*, the power of certain crystals and optically active substances of turning the plane of polarization of light to the right or left hand"—is not only less fundamental but misleads, since it is theoretically possible for crystals of four non-enantiomorphous classes (m, $mm2$, $\bar{4}$, $42m$), which are not chiral in Kelvin's sense, to display optical activity[4], though no example has yet been positively established.

The following generalization of Kelvin's definition is proposed (and has been offered for use in the next Supplement to the Oxford English Dictionary): 'three-dimensional forms (in the widest sense, including point arrangements, structures, fields, displacements, and other processes, periodic and relaxation) which possess non-superposable mirror images are called chiral'. This is a three-dimensional non-relativistic property; a chiral process is one the successive states of which are chiral. The necessary and sufficient condition for the presence of chirality is the absence of all three of the following symmetry elements: a plane of symmetry, a centre of symmetry, and any $4n$-fold inversion axis. The definition applies both to mathematical forms and to observed phenomena, and does not presuppose their representation in any particular manner (for example, in a linear, or any other co-ordinate system, etc.) provided the conceptions of mirror images and of superposition (by rotations) are applicable.

The terms 'chiral', 'chirality', 'chiroid' (for chiral object or process) are short, enjoy a distinguished tradition, and can be given an unambiguous and comprehensive definition. Alternative terms are either less general or vague: 'enantiomorphous', though in origin expressing the same idea, has acquired a narrower application through usage for the eleven chiral classes of point group symmetry and for crystals of these classes; 'asymmetrical' has an established meaning for carbon atoms and other chemical centres, but is otherwise ambiguous; 'non-symmetric' is best restricted to tensors; 'dissymmetric' has been used for chiral molecules and crystals, but not widely adopted; chemically 'isomeric' molecules may not be chiral; while 'anti-symmetrical' has a special meaning[5]—operations of anti-symmetry transform objects possessing two possible values of a given property from one value to the other.

Chiral forms are more varied and widespread than is sometimes realized. Some examples are: (mathematical) skew polygon, pair of skew lines, area with sense, various skew polyhedra, for example, an isosceles tetrahedron with scalene faces and Coxeter's "orthoscheme", helix, helical polygon, scalene spherical triangle, single overhand knot, eleven enantiomorphous classes of point group symmetry, ratio of two co-initial vectors, associations of a polar with an axial vector, quaternions, spinors, non-symmetric three-dimensional tensors, pseudo-scalar fields; (natural) most optically active molecules, crystals of the eleven enantiomorphous classes, many electromagnetic fields, screw displacements, body torques, torsions, relaxation processes of chirally deformed structures, amino-acid and protein structures, conical helices in plants and shells, many parts of animals (including the human hand); (man made) coat with buttoning for man or for woman, shoe, propellor, clock face. They merit a clear designation.

Note added in proof. 'Helicity' is a special case of chirality, involving helical properties with respect to an axis. Recent examples of chiral forms are the neutrino and the chiral operator of particle theory (Watanabe, *Phys. Rev.*, **106**, 1306; 1957).

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Motion of the Nodal Line of the Second Russian Earth Satellite (1957β) and Flattening of the Earth

Despite the fact that the observation of an artificial satellite can be carried out only on a small region of the Earth's surface, we can use these measurements for determining the geocentrical co-ordinates of the satellite, if we know the approximate value of its distance from the Earth's centre. The most suitable observations are those in the neighbourhood of the zenith. If we know the inclination of the orbit, we can then determine also the position of the orbital node.

In order to determine the motion of the orbital node, we used 33 visual observations, made between December 7, 1957, and March 21, 1958, at various places in Czechoslovakia. By adjustment of the positions of the node grouped about five normal positions, the following expression for the right ascension of the ascending node was derived:

$$\Omega = 256{\cdot}59^\circ \pm 0{\cdot}20^\circ - (2{\cdot}9007^\circ \pm 0{\cdot}0046^\circ)(t - t_0) - (0{\cdot}00234^\circ \pm 0{\cdot}00012^\circ)(t - t_0)^2$$

Epoch t_0 = January 22·0, 1958, U.T. Time t is expressed in days. The mean errors were computed from the deviations of the normal places. The daily motion of the node is then given by :

$$\frac{d\Omega}{dt} = -2{\cdot}9007^\circ \pm 0{\cdot}0046^\circ - (0{\cdot}00468^\circ \pm 0{\cdot}00024^\circ)(t - t_0)$$

It is well known that the theoretical value of this motion is given by the approximate equation :

$$\frac{d\Omega}{dt} = -\frac{3k(C-A)}{2ma'^2}(1 + 2e^2)\cos i$$

where $C - A$ is the difference between the moments of inertia of the terrestrial spheroid, m the mass of the Earth and k the gravitational constant. The symbol a stands for the major semi-axis of the orbit, expressed in units of the equatorial radius of the Earth, e and i being the eccentricity and inclination of the orbit, respectively.

It is obvious that, by using this equation, we can derive from the observed motion of the node the quantity $K = \frac{C-A}{m}$. If, for the time $t = t_0$, we assume $a = 1{\cdot}1127 \pm 0{\cdot}0003$ and for e and i the values published by D. G. King-Hele[1], namely, $e = 0{\cdot}0731 \pm 0{\cdot}0005$, $i = 65{\cdot}29^\circ \pm 0{\cdot}03^\circ$, we then arrive at :

$$K = 0{\cdot}0010856 \pm 0{\cdot}0000024$$

The mean error was computed as the total effect of the errors of the basic data. The oblateness of the Earth, α, can be computed from the expression :

$$\alpha = \frac{3}{2}K + \frac{h}{2} + \frac{3}{4}(3K^2 + Kh - h^2)$$

where h is the ratio of the centrifugal force to the value of gravity at the equator.

The reciprocal value of the Earth's flattening is then :

$$\frac{1}{\alpha} = 297{\cdot}7 \pm 0{\cdot}3$$

If we use four more values for a and e determined[2] between February 10 and March 3, 1958, we arrive finally at the result :

$$K = \frac{C-A}{m} = 0{\cdot}0010883 \pm 0{\cdot}0000014$$

$$\frac{1}{\alpha} = 297{\cdot}4 \pm 0{\cdot}2$$

In these numerical results approximate account was taken of the second term of the disturbing function.

These preliminary results show that satellite observations of greater precision will give us the possibility of determining correctly the oblateness of the Earth.

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Effect of Oxygen on the Electron Spin Resonance Spectrum of α,α′-Diphenyl-β-picrylhydrazyl

It has been found that under certain conditions gaseous oxygen can have a marked effect on the electron spin resonance line of α,α′-diphenyl-β-picrylhydrazyl. Normally that substance crystallizes with one molecule of solvent per radical and does not exhibit this 'oxygen effect'. It is possible, however, to remove most of this solvent by heating the radical at 80° C. under high vacuum for several days. (There is no evidence that the radical is destroyed by this treatment.) The magnitude of the resonance line from a treated sample of α,α′-diphenyl-β-picrylhydrazyl depends strongly on the pressure of oxygen over the sample. The effect is similar to that observed in carbons, and appears to be a combination of the two extreme cases reported[1].

The electron spin resonance measurements were made at room temperature using a 3-cm. wave-length crystal-video spectroscope. The dependence of the width and apparent intensity of the resonance line on oxygen pressure has been studied (Fig. 1). In addition, the effect of altering the percentage of oxygen in an oxygen–nitrogen mixture has been observed. These latter results are identical with the former if the amount of oxygen present in the mixture is expressed in terms of its partial pressure. In both cases the effect of oxygen on the electron spin resonance line was completely reversible.

When the atmosphere surrounding the sample was changed from oxygen to nitrogen, or vice versa, a corresponding change in the resonance line occurred almost instantaneously. The fact that this change could be produced simply by displacing one gas by the other suggests that there is a dynamic interaction occurring between oxygen molecules and the unpaired electrons of the α,α′-diphenyl-β-picrylhydrazyl.

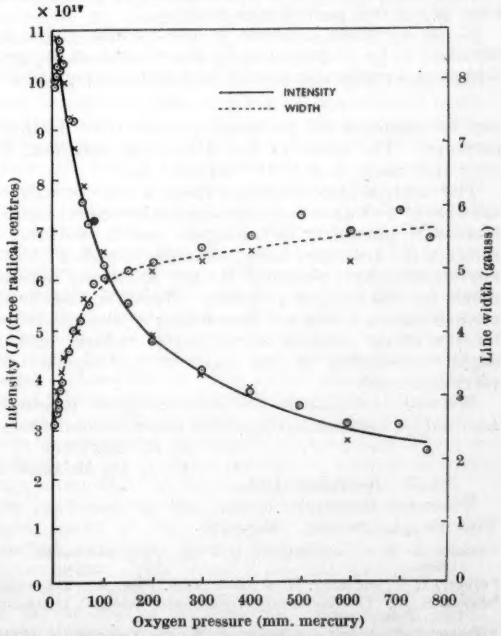

Fig. 1. Variation of intensity and width of resonance line with pressure of oxygen

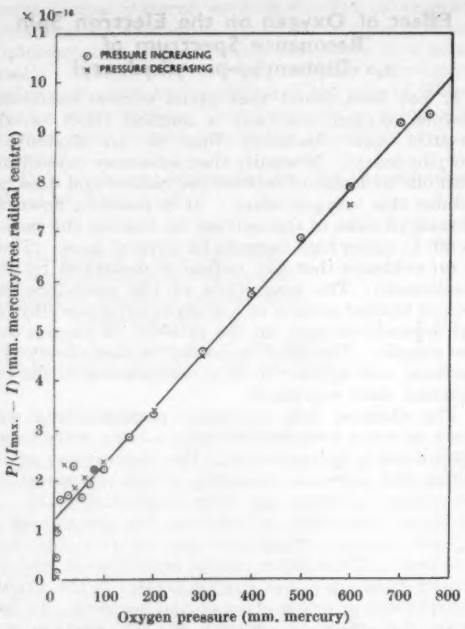

Fig. 2. Langmuir plot for adsorption of oxygen on α,α′-diphenyl-β-picrylhydrazyl

The results indicate that the interaction is physical rather than chemical in nature. It is unlikely that the decrease in the intensity of the resonance line is due to an actual decay of the free radical concentration, but that the line is broadened beyond detection. This broadening would appear to be similar to that postulated for carbon[2], where the interaction with the oxygen molecules decreases the spin-lattice relaxation time of the free radical spin system.

If the apparent decrease in the resonance line is assumed to be proportional to the volume of oxygen adsorbed, a reasonable plot of the Langmuir equation[3]:

$$p/v = 1/v_m b + p/v_m$$

can be obtained for pressures greater than 25 mm' mercury. The value of the adsorption constant, b over this range is 7×10^{-6} dynes^{-1} cm.^{2}.

The electron spin resonance spectra from powdered samples of 1 : 3-dimethyl-1-(phenylimine oxide)-butylidene-3-N′-phenyl-N′-oxynitrogen[4] and 2 : 6-di-tert.-butyl-4-(3 : 5-di-tert.-butyl-4-oxocyclohexa-2 : 5-dienylidenemethyl) phenoxy[5] do not show any dependence on the oxygen pressure. However, dissolved oxygen causes a marked broadening of the spectrum from a dilute solution of the latter radical, and a slight broadening in the case of α,α′-diphenyl-β-picrylhydrazyl.

We wish to thank the Directors of 'Shell' Research Limited for permission to publish this communication.

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E. J. H. Morgan

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Thornton Research Centre,
P.O. Box 1, Chester. May 22.

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Entry of Water into Silica Glass

Some specimens of silica glass absorb infra-red radiation of wave-length near 2·7μ. Garino-Canina[1] observed that the occurrence or absence of the band in his specimens depended on whether or not water vapour was present when the glass was made (by fusing quartz crystal). Following Harrison[2], he attributed the absorption to hydroxyl groups bound to some of the silicon ions of the glass.

We have demonstrated the ability of the absorbing centres to diffuse into the glass at temperatures low compared with the softening point. Values of diffusion coefficient and solubility have been obtained.

Specimens not showing the absorption band were heated at constant temperature and in a constant pressure of water vapour. The optical density of the band ($\log_{10}(I_0/I)$, where (I_0/I) is the ratio of radiation incident on the specimen to that transmitted) increased with the square root of time, suggesting that the number of absorbing centres present at any time was controlled by a diffusion process within the glass.

The distribution of the absorbing centres inside the laminar specimens of glass used was investigated by sectioning. The optical density was measured at each stage after successive layers of thickness about 10μ were removed from the surfaces of the specimen by grinding and re-polishing. Considerable penetration was found: for example, after 36 hr. at 1,160° C., absorption was detectable to a depth of 200 μ. The penetration profile appeared to be smooth and of the shape to be expected for diffusion in the existing boundary conditions.

The diffusion coefficient of the absorbing centres was determined as follows. One 'thick' and one 'thin' specimen were heated under the constant conditions of temperature and pressure of water vapour. The thickness of the 'thick' specimen was large compared with the diffusion distance, while that of the 'thin' one was small enough to allow saturation of the glass with the absorbing centres to be reached during the experiment. With the assumptions that the concentration of centres in the saturated thin specimen was uniform, and that this concentration was identical with that at the surface of the thick specimen (both assumptions being supported by experimental evidence from the sectioning work), the diffusion coefficient, D, was evaluated directly from the optical densities of the two specimens. Between 600° C. and 1,200° C., D could be represented by:

$$D = (1{\cdot}0 \pm 0{\cdot}2) \times 10^{-6} \exp\left(-\frac{18300 \pm 500}{RT}\right) \text{cm.}^2 \text{ sec.}^{-1}$$

where R is the gas constant in cal./mole and T is the absolute temperature.

If the water reacts with the glass to form groups of the type (—Si—OH), their number may be estimated from the optical density provided the extinction coefficient is known. An estimate of the value of this coefficient was made by determining the extinction coefficient for the hydroxyl group in the unassociated molecule of triphenylsilanol (in which the —Si—OH group also occurs). The observed optical densities then led to values of solubility, under a pressure of 700 mm. mercury water vapour, ranging from 6×10^{-3} to 3×10^{-2} hydroxyl groups per 'silica molecule' between 600° and 1,200° C., respectively.

The dependence of the equilibrium concentration of absorbing centres on pressure of water vapour at constant temperature is at present under investigation.

One of us (A. J. M.) thanks the Director of the British Ceramic Research Association, for leave of absence and financial support.

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J. P. Roberts

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May 22.

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Diffusion of Adsorbed Molecules

In a recent monograph[1], Carman dismisses the suggestion that the spreading pressure φ is the operative force in the diffusion of adsorbed molecules with the statement that the coefficient of resistance of such an equation varies more rapidly with concentration than does the diffusion coefficient of Fick's equation. In presenting his arguments for this view, Carman gives for diffusion under a spreading pressure the equation :

$$-\frac{W_s}{At} = B_\varphi \frac{\partial \varphi}{\partial x} \qquad (1)$$

where W_s/At is the number of moles diffusing across unit area of adsorbent in time t under the influence of a gradient $\partial\varphi/\partial x$ of the spreading pressure. $1/B_\varphi$ is a two-dimensional resistance constant.

This equation does not represent the theory previously presented by me for the diffusion of adsorbed molecules. In the development of the equations for diffusion[2], I assumed the fundamental dynamical equation for the diffusion of an adsorbed gas to be :

$$\frac{\partial \varphi}{\partial x} + C_r u = 0 \qquad (2)$$

where C_r is a coefficient of resistance and u is the resultant velocity of motion of the adsorbed film on the surface. From this equation,

$$u = -\frac{1}{C_r}\frac{\partial \varphi}{\partial x} \qquad (3)$$

and

$$\frac{W_s}{At} = \frac{Nu}{N_A} = -\frac{N}{C_r N_A}\frac{\partial \varphi}{\partial x} \qquad (4)$$

where N is the number of adsorbate molecules per unit volume of adsorbent and N_A is Avogadro's number. Equation 4 differs from equation 1 by the factor N and the presence of N destroys Carman's argument.

In these equations it is assumed that C_r, which is equal to the resistance force per unit volume at unit velocity, is a constant independent of N. An alternative assumption is that the resistive force per molecule is independent of N. This second assumption was investigated in a subsequent paper[3] and was found to be unsatisfactory. If C_m is the coefficient of resistance per adsorbed molecule :

$$C_r = C_m N \qquad (5)$$

and

$$\frac{W_s}{At} = \frac{Nu}{N_A} = -\frac{1}{C_m N_A}\frac{\partial \varphi}{\partial x} \qquad (6)$$

This equation is equivalent to equation 1 used by Carman. His argument, therefore, applies only to an equation which had already been tested and rejected.

The assumption in equation 2, that the resistive force per unit volume is independent of N, requires that the resistive force per molecule varies as $1/N$. Since it is natural to assume that resistive forces are proportional to the energy with which the molecules are bound to the surface, we should expect equation 2 to be applicable only to adsorptions where the differential heats are inversely proportional to the number of atoms adsorbed. That the equation can be applied to the diffusion of adsorbed gases is undoubtedly due to the fact that most heats of adsorption can be roughly represented by a hyperbolic curve. It follows from these arguments that, when this is not so, or when more precise representation is required, it will be necessary to use an expression for the resistive force that corresponds more closely to the measured heats of adsorption.

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In the brief treatment of Babbitt's theory in my book, equation 1 of the above communication was used, and it was pointed out that, with the experimental data available, B_φ, instead of being a constant, actually varied more rapidly with surface concentration than the surface diffusion coefficient which arises from Fick's equation. Babbitt now points out that, in the form of the theory which he has advocated, the correct expression is given by equation 4. According to this, the quantity which should be constant is not B_φ, but B_φ/N, where N is a measure of the surface concentration.

When this was applied to the data of Carman and Raal, it was found that B_φ/N in all cases varied much less than the surface diffusion coefficient and sometimes showed a remarkable constancy. Thus, for 'Freon 12' (CF_2Cl_2) on Linde silica, it showed little variation from a surface concentration of about one-half monolayer to about two and one-half monolayers, even though the surface diffusion coefficient passes through a maximum in this range. At higher concentrations it increases, but this could probably be ascribed to the action of capillary forces on capillary condensate. For sulphur dioxide on Linde silica, it is not quite so constant, but increases very little from one-half to two and one-half monolayers. Thereafter it rises fairly rapidly. In the case of 'Freon 12' and of carbon dioxide on 'Carbolac', it is only possible to state that, on the whole, the range of variation is less than for the surface diffusion coefficient ; but it is not possible to distinguish any range where B_φ/N is even approximately constant.

As explained by Babbitt, a constant value of B_φ would result if the coefficient of resistance per adsorbed molecule were independent of surface concentration. This seems a natural assumption to make, but it was rejected by Babbitt because it did not fit the results of King for diffusion of water vapour through horn. He has preferred, therefore, to assume B_φ/N or C_r is a constant, and, on this basis,

it can be seen that his theory deserves serious consideration, though it does not apply quantitatively to all systems.

Note added in proof. A rather remarkable further confirmation of Babbitt's equation has been given recently by Gilliland, Baddour and Russell[1] for flow in porous glass plugs.

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Rubidium Depletion in Feldspars

The close geochemical coherence of potassium and rubidium has been emphasized in a number of papers by Ahrens and co-workers[1–4].

This coherence is shown in Fig. 1. The dashed lines on the diagram indicate the limits of scatter of Ahrens's original data, and most subsequent analyses fall within these limits, which are taken to indicate the limits of 'normal' potassium/rubidium ratios. In view of the close coherence of potassium and rubidium in a wide variety of igneous, metamorphic and sedimentary rocks (as well as chondritic meteorites and tektites), variations in the potassium/rubidium ratios beyond the normal limits indicate extreme processes, capable of fractionating potassium and rubidium (providing that the analyses are of satisfactory precision and accuracy).

Relative enrichment in rubidium has long been known from the special geological environment of large pegmatite bodies[2,5]. This has usually been ascribed to extreme magmatic or metamorphic differentiation causing the 10 per cent difference in ionic radius between K^+ (1·33 A.) and Rb^+ (1·47 A.) to become effective. The points lying in area I of Fig. 1 represent analyses of alkali feldspars from some large pegmatites. Recently, the same trend has been recognized in some rhyolites and granites which have crystallized from highly fractionated magma[6]. The analyses of these rocks fall in area II of Fig. 1.

Relative impoverishment or depletion of rubidium has occasionally been noted in rocks (Ahrens, personal communication; Upton, personal communication; Heier, unpublished results) and some published results of Tolmachev and Filipov[7] indicate high potassium/rubidium ratios in nepheline[5].

Recent work at Oxford has provided definite anomalously low rubidium values in several alkali feldspars. In view of the established potassium/rubidium coherence these few abnormal potassium/rubidium ratios indicate unusual conditions. These analyses fall in area III of Fig. 1.

The feldspars which have abnormal ratios come from arendalite (=charnockite) near Arendal, South Norway (full circles, Fig. 2), and syenites and monzonites (crosses) from granulite facies rocks at Langøy, Lofoten Islands, Northern Norway. These feldspars are mesoperthites[8].

In Fig. 2 the calculated orthoclase (*Or*), albite (*Ab*) and anorthite (*An*) values for these feldspars are plotted. The shaded area represents the composition of about eighty alkali feldspars with normal potassium/rubidium ratios. This figure is a projection of the quaternary system $NaAlSi_3O_8$(*Ab*)–$KAlSi_3O_8$(*Or*)–$CaAl_2Si_2O_8$(*An*)–H_2O at 5,000 bars water pressure[9]. Analyses are plotted as weight

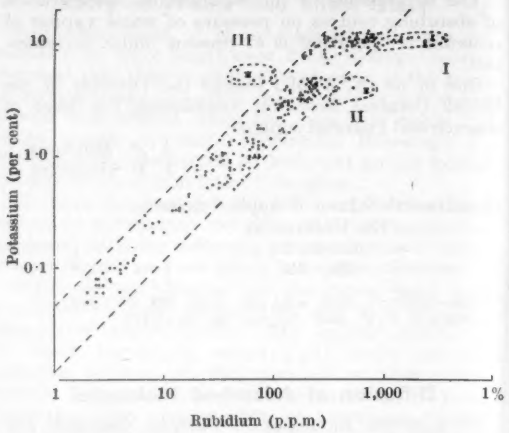
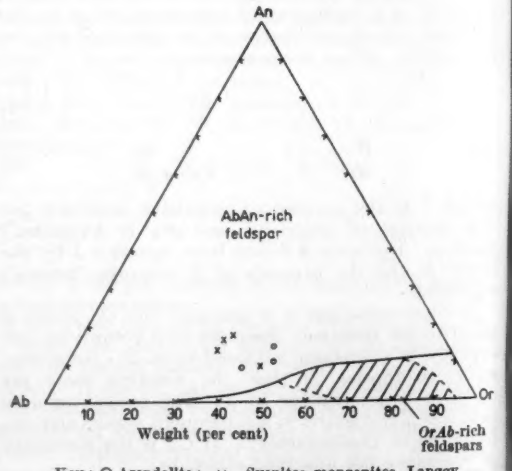


Fig. 1. Potassium–rubidium relationship for rocks and meteorites. Dashed lines indicate limits of scatter of 'normal' potassium/rubidium ratios. Area I includes feldspars from large pegmatites showing enrichment in rubidium; area II includes granites and rhyolites enriched in rubidium (ref. 6); area III includes feldspars depleted in rubidium

per cent *Or*, *Ab* and *An*. The cotectic curve separating the fields from which *OrAb*-rich feldspars and *AbAn*-rich feldspars crystallize out is indicated.

Our results indicate that rubidium is preferentially excluded from alkali feldspars, which, although containing substantial amounts of potassium, have a composition which places them in the *AbAn*-rich field of Fig. 2, but close to a composition from which an *OrAb*-rich feldspar would crystallize as a stable phase. It is of interest to note that the *AbAn*-rich feldspars impoverished in rubidium lie close to the maximum of the subsolidus curve for alkali feldspars separating the one and two feldspar regions, indicating maximum instability for a single feldspar phase. Where an *AbAn*-rich phase separates, the number of co-ordination sites available for potassium must be



Key: ○ Arendallite; ×, Syenites–monzonites Langøy

Fig. 2. Feldspar compositions plotted on the projection of the quaternary system $NaAlSi_3O_8$(*Ab*)-$KAlSi_3O_8$(*Or*)-$CaAl_2Si_2O_8$(*An*)-H_2O at 5,000 bars water pressure (ref. 9). The shaded area represents the composition of about 80 alkali feldspars with normal potassium/rubidium ratios

restricted. In this case, the 10 per cent difference in size is liable to become critical, and K^+ may preferentially enter the lattice at the expense of RB^+. If much Ba^{2+} (1·34 A.) is present this may also occupy the high co-ordination sites to the exclusion of rubidium. This hypothesis for rubidium depletion implies that the feldspar crystallized as a homogeneous phase, and that in these cases the mesoperthite structure is due to unmixing and not to replacement.

It should be noted that a purely structural explanation for the exclusion of rubidium cannot be completely valid, since plagioclase feldspars have normal potassium/rubidium ratios. (This is indicated by the normal ratios of basic and intermediate igneous rocks, and also by the few analyses of plagioclase feldspars available.)

The additional factor seems to be the concentration of potassium in the system from which the feldspar is crystallizing. In the cases where rubidium is depleted, the system has a composition very close to the point where an independent *OrAb*-rich feldspar will appear as the stable phase. Potassium is thus very abundant and may be thought of as 'forcing' itself into the crystal lattice, which has a restricted number of sites for large ions. Rubidium, present in much smaller amounts and at a size disadvantage in this competition, will be excluded in favour of potassium in this somewhat unusual case.

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Invertase Activity in Clay Mineral - Soil Mixtures

It has been demonstrated that clay minerals can inhibit several enzymes. For example, adsorption of yeast invertase on kaolinite produces a partial inactivation of the enzymic activity, which however continues slowly[1]. By adsorption of yeast invertase on bentonite at *p*H 2·9 the enzyme is rapidly inactivated[2]. The activity of nuclease is also reduced in presence of bentonite[3]. Montmorillonite, illite and kaolinite inhibit several phosphatases[4]. McLaren has also reported that adsorption of enzymes on kaolinite may lead to a reduction or complete loss of their activity[5]. Cellulase and hemicellulase activity is reduced in the presence of montmorillonitic clays[6]. From these experiments, suggestions have been made of the possible role of the inhibition of enzymes by clay minerals in the hydrolysis of organic compounds in soil, and in humus formation.

Soil, such as clay minerals, adsorbs enzymes such as jackbean urease[7] and yeast invertase[8]. It has also been observed that added enzyme (wheat bran phytase) is not inactivated by soil[9]. The original phosphatase content of the soil suffers no reduction in its activity when clay minerals are added to soil[10]. My previous investigation[11] showed that the original natural invertase of the soil, like phosphatase, undergoes no inactivation in clay mineral – soil mixtures; on the contrary, I observed a very much increased invertase production in these mixtures, induced by the specific enzyme substrate (sucrose).

If, in these clay mineral – soil mixtures, the original natural invertase content of the soil is protected from the inhibiting action of the clay minerals, then it is still uncertain if this protective effect of the soil is a general property and so valid also for an added invertase preparation.

This problem has been studied with a neutral degraded chernozem soil (humus content 4·27 per cent), kaolinite (*S* value, 9·60 m.equiv./100 gm.; *T* value, 18·90 m.equiv./100 gm.), bentonite (*S* and *T* values, 55·60 m.equiv./100 gm.), and a yeast invertase preparation. One series of samples contained clay minerals in different quantities plus a constant volume of the yeast invertase solution; another series contained clay minerals in different quantities plus a constant quantity of soil (20 gm. air-dry soil) plus a constant volume of the yeast invertase solution. As controls, we used soil alone and yeast invertase alone. To all samples toluene was added to suppress microbiological activity, buffer solution (2 *M* Na_2HPO_4 / 2 *M* CH_3COOH, 1 : 1) at *p*H 5·5, and sucrose solution as enzyme substrate. Incubation was for 4 hr. at 37° C. The rate of inversion was determined polarimetrically. For obtaining clear solutions for polarimetry, our previous procedure was used[12]. For polarimetry we used a 2-dm. tube with light from a sodium lamp, and a temperature of 20° C. Invertase activity is expressed as the difference between rotations before and after incubation. No adsorption was observed of the sucrose or its hydrolysis products by the clay minerals, soil or the mixtures used. The results of the invertase activity determinations are given in Fig. 1.

It can be seen that the clay mineral – soil mixtures, like soil, have only a minimal inhibiting action on the yeast invertase; the attenuation of the activity of yeast invertase by the clay minerals is prevented by adding soil to the clay minerals.

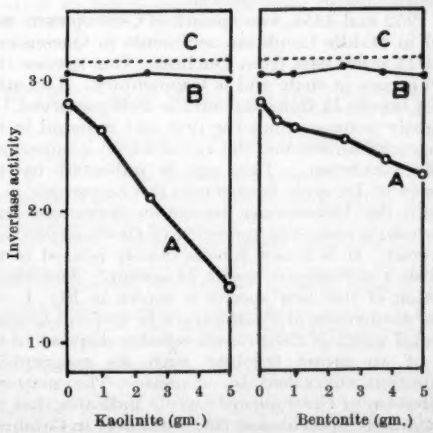

Fig. 1. Activity of yeast invertase in the presence of clay minerals, *A*, and of clay mineral – soil mixtures, *B*. The straight line *C* represents the sum of the activities of the soil invertase alone and of yeast invertase alone

This work indicates that data on enzyme inhibition by clay minerals cannot be applied directly to processes in soil because of its protecting effect.

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The Middle Cambrian Trilobite *Centropleura* in Queensland

The trilobite genus *Centropleura* Angelin 1854 was established for a Swedish species, *Paradoxides lovéni* Angelin 1851. *Centropleura lovéni* occurs in the Middle Cambrian Andrarum limestone of Scania, Sweden. During the century that followed its first discovery, the genus was found in rocks of the same Middle Cambrian age on Bennett Island in the Arctic Ocean, in northern and eastern Siberia, in the United States in the State of Vermont, and in Canada in the eastern part of the Gaspé Peninsula. It was assumed that *Centropleura* was an 'arctic' and 'subarctic' trilobite.

In all these localities *Centropleura* is rare and is preserved as fragments unsuitable for reconstructing the exoskeleton. Angelin published a reconstruction that has been reproduced from time to time in the subsequent literature. This reconstruction is still incomplete and is, apparently, based on two different species. An almost complete specimen of a related form ("*Anopolenus*") was described from Great Britain. Although this specimen is strongly sheared, it shows an organization different from Angelin's reconstruction of *Centropleura*.

In 1952 and 1954, two species of *Centropleura* were found in Middle Cambrian sediments in Queensland, 6 and 15 miles east from Duchess. One species (the older) occurs in shale and is fragmentary. The other species occurs in limestone and is well preserved. It is slightly younger than the first and is found in the Devoncourt Limestone, the age of which is uppermost Middle Cambrian. This age is indicated by the presence of *Leiopyge laevigata* in the Limestone.

From the Devoncourt Limestone numerous fragments and a complete specimen of *Centropleura* were recovered. It is a new species closely related to the Swedish *Centropleura lovéni* (Angelin). The reconstruction of this new species is shown in Fig. 1.

The occurrence of *Centropleura* in tropical Queensland and south of the present equator disposes of the idea of an arctic trilobite with its geographical distribution controlled by climate. The scattered distribution of *Centropleura* merely indicates that the seaways were open almost the world over in Cambrian time.

Centropleura, as seen from the reconstruction (Fig. 1), deviates in its organization from other

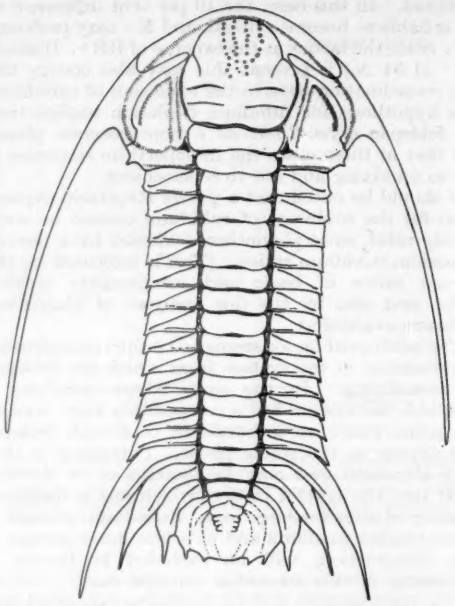

Fig. 1. *Centropleura* n.sp. (reconstruction one-third natural size); Devoncourt Limestone, Queensland

trilobites in several ways. Its three posterior thoracic segments are macropleural and are linked with each other and with the pygidium into a rigid, non-articulating unit. This 'pygidial unit' functioned even as a moulting unit, although after moulting it could disintegrate into its four original components. The rigidity of the unit results from the backward curvature of the line of contacts between the posterior tergites, whereas flexibility along the contacts is possible only where they are straight hinge lines, as is seen between the remaining thirteen segments and the cephalon. These thirteen segments also have unusual short pleuræ with an extremely narrow doublure. The hour-glass shape of the thorax is unique.

A rostral shield fused with the hypostoma is also preserved.

Centropleura is at present assumed to be a genus of the family Paradoxididae. Its expanded glabella and the character of the posterior glabellar furrows may support this view. However, the structure of the thorax and of the pygidium, the deep interlocking of the free cheeks and cranidium, and the advanced position of the cephalic spines, including the intergenal spines, do not support the assumption of a close relationship between *Paradoxides* and *Centropleura*.

A complete description of the new species of *Centropleura* and the associated fossils is in preparation and will be published in a forthcoming bulletin of the Bureau of Mineral Resources, Geology and Geophysics.

This communication is published by permission of the Secretary, Department of National Development, Canberra, A.C.T.

A. A. Öpik

Bureau of Mineral Resources,
Geology and Geophysics,
Childers Street, Turner,
Canberra. May 5.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, July 21

PALÆONTOLOGICAL ASSOCIATION (in Meeting Room J, Royal School of Mines, Prince Consort Road, London, S.W.7), at 2.30 p.m.—Prof. T. N. George: "Evolution and the Palæontological Record".

Wednesday, July 23—Wednesday, July 30

ROYAL MICROSCOPICAL SOCIETY (at the Polytechnic School of Photography, 309 Regent Street, London, W.1)—"Micro 58": an Exhibition of Photography with the Microscope.* (July 23rd, Fellows and Invitation only.)

Thursday, July 24

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at the Hospital for Tropical Diseases, 4 St. Pancras Way, London, N.W.1), at 7.30 p.m.—Clinical Meeting. Chairman: Brigadier J. S. K. Boyd, O.B.E., F.R.S.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN AGRICULTURAL ECONOMICS—The Registrar, The University, Manchester 13 (July 23).

ASSISTANT LECTURER IN PHYSICAL-ORGANIC CHEMISTRY—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 23).

LECTURER (with a good degree in chemistry and appropriate teaching, research or industrial experience) IN SPECTROSCOPY, for duties which will include teaching spectroscopy to Diploma in technology and Degree standard and special postgraduate courses for industrial chemists—The Principal, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3 (July 25).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, The University, Liverpool (July 26).

ASSISTANT (with a first- or second-class honours degree in biochemistry or chemistry) IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh (July 26).

ENGINEERS, CHEMICAL ENGINEERS or PHYSICISTS (at least 26 years of age, with a good university degree, or Corporate Member of a senior engineering institution, and preferably industrial experience), for training as REACTOR TECHNOLOGISTS—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2476 (July 28).

ASSISTANT LECTURER IN MATHEMATICS—The Registrar, University College of Wales, Aberystwyth (July 31).

HEAD OF THE DEPARTMENT OF MATHEMATICS AND PHYSICS (Grade B), Kumasi College of Technology—Council for Overseas Colleges of Arts, Science and Technology, 12 Lincoln's Inn Fields, London, W.C.2 (July 31).

SIR ALAN COBHAM RESEARCH FELLOW IN AERONAUTICS to carry out research in one of the following subjects: (*a*) aircraft noise and structures, (*b*) hypersonics, (*c*) helicopter vibrations, (*d*) jet flap investigations, or (*e*) numerical methods applied to wing design—The Secretary and Registrar, The University, Southampton (August 1).

RESEARCH WORKER IN PSYCHOLOGY—The Registrar, The University, Sheffield (August 2).

DEMONSTRATOR IN PHYSIOLOGY—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne (August 6).

LECTURER/SENIOR LECTURER (preferably with some experience in the field of aeroelasticity) IN AERONAUTICAL ENGINEERING at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 9).

LECTURER (with a university degree in engineering or science at honours level) IN ELECTRICAL ENGINEERING at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 9).

CLINICAL VETERINARY PATHOLOGIST (with experience in all veterinary pathological investigations) at the University of Sydney Veterinary Hospital at Camden, for duties which will include the diagnostic examination of clinical material, teaching and research—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

LECTURER (with an honours degree in physics, preferably able to teach the subject to a high standard, and with teaching, industrial or research experience) IN PHYSICS—The Principal, Wigan and District Mining and Technical College, Wigan (August 15).

LECTURERS (2) IN PSYCHOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

SENIOR LECTURER (with an honours degree in science) IN HISTORY AND METHOD OF SCIENCE at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

RESEARCH FELLOW (with a Ph.D. degree in the relevant branch of chemistry with some additional experience, preferably with the Group 8 elements) IN THE BIOLOGICAL INORGANIC CHEMISTRY UNIT, John Curtin School of Medical Research, Australian National University, to carry out fundamental research on the synthesis of co-ordination compounds of the heavier transitional elements—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 19).

LECTURER (with at least an honours B.Sc.) IN ZOOLOGY at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 30).

RESEARCH ASSISTANT (with an honours degree in biochemistry or pharmacology), to work on the biochemistry of hypoglycæmic sulphonamides—The Department of Pharmacology and Therapeutics, Queen's College (University of St. Andrews), Dundee (August 30).

LECTURER (with an honours degree or a higher degree in chemical engineering or equivalent qualifications, and preferably an interest in mass transfer) IN CHEMICAL ENGINEERING at the University of Canterbury, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

LECTURER OR SENIOR LECTURER IN HISTORY AND PHILOSOPHY OF SCIENCE at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 31).

SENIOR LECTURER IN INORGANIC AND ANALYTICAL CHEMISTRY at the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

NON-STATUTORY LECTURER IN PHYSICAL CHEMISTRY—Prof. T. S. Wheeler, Department of Chemistry, University College, Dublin (September 1).

PROFESSOR OF HORTICULTURE—The Secretary and Bursar, University College, Dublin (September 1).

READER IN FLUID MECHANICS at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 11).

HEAD (with at least a first-class honours degree in botany, agricultural botany or equivalent and preferably with suitable postgraduate research experience) OF THE DEPARTMENT OF PLANT PHYSIOLOGY—The Secretary, The Grassland Research Institute, Hurley, Near Maidenhead, Berks (September 15).

LECTURER IN PURE MATHEMATICS—The Registrar, The University, Hull (September 15).

ASSISTANT (Grade B) TO TEACH CHEMISTRY WITH SOME PHYSICS OR MATHEMATICS—The Principal, North-West Kent College of Technology, Miskin Road, Dartford, Kent.

ASSISTANT LECTURER IN CROP HUSBANDRY, and an ASSISTANT LECTURER IN AGRICULTURAL CHEMISTRY—The Principal, Seale Hayne Agricultural College, Newton Abbot, Devon.

ASSISTANT LECTURER IN MATHEMATICS—The Secretary, The Royal College of Science and Technology, Glasgow.

EXPERIMENTAL OFFICER (not under 26 years of age, with at least H.S.C. (Science) or equivalent and extensive experience in metallurgical analysis, including the analysis and control of trade waste effluent, and preferably several years supervisory experience), to be responsible to the Laboratory Manager for the work of a small team engaged on general inorganic chemical analysis—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. A/1736/34.

LECTURER/DEMONSTRATOR IN THE CHEMISTRY DEPARTMENT—The Bursar, Royal Agricultural College, Cirencester.

READER (with a degree of a British university and research qualifications in some branch of applied mathematics or statistics) IN APPLIED MATHEMATICS—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

RESEARCH STUDENTS IN ORGANIC AND INORGANIC CHEMISTRY—The Secretary and Registrar, The University, Southampton.

SCIENTIFIC OFFICER (with a first- or second-class honours degree in mathematics, science or economics) AT THE BUILDING RESEARCH STATION (D.S.I.R.), Garston, Watford, for work in a section dealing with information and publicity through exhibitions, press, etc., secretarial work for home and European scientific committees, patents, and general central administration on scientific matters—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.242/8A.

SENIOR LECTURER or LECTURER IN THE DEPARTMENT OF AERODYNAMICS, for lecturing to, and supervising work of, postgraduate students in the field of stability and control—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

Anti-Locust Bulletin No. 30: Oviposition Behaviour and Egg Mortality of the Desert Locust (*Schistocerca gregaria* Forskål) on the Coast of Eritrea. By W. J. Stower, G. B. Popov and D. J. Greathead. Pp. 33+17 figures. (London: Anti-Locust Research Centre, 1958.) 7*s*. [195

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Report of the Rugby School Natural History Society for the year 1957. Pp. 28+1 plate. (Ninety-fifth issue.) (Rugby: Rugby School Natural History Society, 1958.) [235

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